THE NATURE OF SEMI-AUTONOMOUS WORK GROUP STRUCTURE: AN INTEGRATION OF THE SOCIOTECHNICAL SYSTEMS APPROACH AND GROUP DEVELOPMENT THEORY

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1987

To my parents,

Lorene Mary Rossman Vaverek and Jerome C. Vaverek

ACKNOWLEDGMENTS

This dissertation would have been impossible without the help and support of many individuals. A great debt is owed my committee: Professor Henry Tosi, Professor John James, and Professor H. Russell Bernard. Each contributed of his unique talents unselfishly and for this I am thankful. Professor Tosi provided patient help with the theoretical development and editing. Professor Bernard guided the statistical methodology and analysis. Professor James was a constant source of reassurance.

My friends, Janice Zahrly, Martin Grace, and Linda Hinkin, were tremendously supportive throughout this endeavor. In addition, Dr. Janice Zahrly collected the data.

This project could not have been completed without the cooperation of the employees and management at the study site. They were gracious in allowing a study of this depth. National Science Foundation research grants (83011109 and 83052712) were awarded to Professor Tosi to fund this study. I was supported as a graduate research assistant under the grants.

The greatest debt is owed my family. My sisters, Kerry, Katy, and Colleen, and my brothers, Kevin, Chris, and

Carter, were always there to give me encouragement while insuring that I kept this goal in perspective. My parents were always willing to listen to the trials and tribulations of their daughter. Although I had doubts, they never did. I thank my entire family for their support and love.

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Abstract of Dissertation Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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May 1987

Chairman: Henry L. Tosi
Major Department: Management and Administrative Sciences

The sociotechnical systems (STS) approach and group development theory were used to examine the social structure of semi-autonomous work groups. Proponents of STS advocate the joint optimization of man and machine through the use of an autonomous work group structure. A four-stage model of group development was used to identify the process through which this optimization occurs.

The research was conducted in a newly created organization designed, constructed, and staffed in accordance with STS principles.

Several hypotheses related to the development of work group structure were examined. Work group structure was measured by the intra-work group production communication network. The relationship between structural subgroups, technological factors, and personal characteristics was

examined over time. Few subgroups were formed on the basis of the individual's age or work as a central life interest similarity. Technological factors were influential in structural differentiation. The lack of attraction based on personal characteristics could be the result of a lack of opportunity for interaction among the workers. Alternatively, it could be the result of methodological considerations. The influence of technical factors was attributed to the "non-routineness" of the task. The STS approach should consider inclusion of the technical imperative in future theoretical developments.

A second set of hypotheses concerned the stages of group development of the work teams. Using group cohesiveness and the number of structural subgroups over time, the conflict stage (2) of group development was identified. Confirmation of the developmental stages, orientation (1), conflict (2), cohesiveness (3), and maturation (4), was procured from observational field notes. Work teams were inconsistent in the timing of the developmental stages despite a constant technical system.

The relationship between structure and performance was examined at both the individual and group levels. The congruence between the social and technical systems was negatively related to group production. There was a positive relationship between an individual's membership in a stable dyad and his or her performance. There was no

relationship between membership in a stable dyad and job satisfaction.

CHAPTER I

THEORETICAL DEVELOPMENT AND RESEARCH HYPOTHESES

This study is about work group structure. It examines the influence of individual and technological factors on the sociotechnical system (STS). The Smithton plant began operation in late 1982. The plant started with a single production line (module), staffed by four semi-autonomous work groups. A second module was added in April 1983 and the capacity of the plant doubled. The final module was added in August 1983. Plant capacity increased by a third. The rate of the equipment additions was not reflected in the rate of the employee additions. For example, production capacity doubled in April 1983, but work team membership increased by only 29%.

As additional equipment was added, the effects of technology on the interactions of work group members became stronger. This is represented in Figure 1. The capacity of the equipment acted as a production ceiling. The actual production limited the resources that could be devoted to interpersonal considerations by dictating the levels of time and energy necessary for task accomplishment. The difference between peak production and actual production is an area of behavioral latitude (shaded portion of Figure 1).

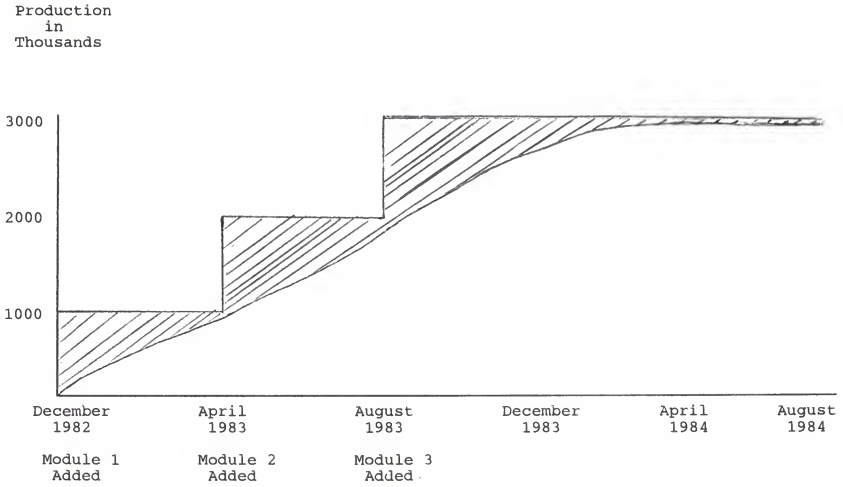


Figure 1

Production and Technological Constraints

As each module was added, the amount of behavioral flexibility decreased. The effect of these constraints on work group structure and work group development is the focus of this dissertation.

The study is theoretically based on the sociotechnical systems (STS) approach and group development literature. STS concepts include development of responsibility, cooperation, and collegiality among individuals, a participative style of management, and the use of work groups to achieve social and technical system optimization. STS does not specify the process through which the joint optimization occurs. Rather, it assumes a smoothly functioning autonomous work group accommodating the technology in a "natural" way. The interpersonal adjustments and technical difficulties which usually accompany organizational creation are generally ignored. Group development theories were used to help understand the growth and development of work groups in this setting.

The Sociotechnical Systems Approach

The sociotechnical systems (STS) approach is based on the work of Trist, Bamforth, and their colleagues at the Tavistock Institute of Human Relations (Trist and Bamforth, 1951; Trist, Higgins, Murray, and Pollock, 1963; Herbst, 1975; Susman, 1976).

> The concept of the sociotechnical system is based on the simple fact that any production system requires both a technology--machinery, plant layout, raw materials--and a work relationship structure that

> relates the human operators both to the technology and to each other. The technology makes demands and places limits on the type of work structure possible, while the work structure itself has social and psychological properties that generate their unique requirements with regard to the task to be done. (Cooper and Foster, 1971: 467)

Sociotechnical Systems Principles

The objective of STS is to make maximal use of the resources of both the social and technical systems (Susman, 1976). In classic organizational theory, human resources are considered interchangeable elements. Technology is the major determinant of the structure of an organization. In STS, the needs and expertise of individuals are also considered in defining an organizational structure. A comparison of the principles of classic organizational theory and the principles of the STS approach is presented in Table 1.

Sociotechnical Systems Characteristics

By changing the focus from conventional technocratic issues to the interdependence of the technical and social systems, a new set of optimal organizational characteristics was developed. Table 2 compares the characteristics of the classical organization with those based on STS. STS characteristics include autonomous work groups, a participative style of management, and member commitment. They provide the necessary flexibility for structuring a system which will integrate the social and technical components.

Table 1

Comparison of the Principles of the Classical and Sociotechnical Systems Approaches

Classical Approach	Sociotechnical Systems Approach
The technological imperative	Joint optimization
Man as an extension of the machine	Man as complementary to the machine
Man as an expendable spare part	Man as a resource to be developed
Organization's purposes only	Members' and society's purposes also

Adapted from Trist (1981).

Table 2

Comparison of the Characteristics of the Classical and Sociotechnical Systems Approaches

Classical Approach	Sociotechnical Systems Approach
Maximum task breakdown simple narrow skills	Optimum task groupings, multiple broad skills
External controls (supervisors, specialist staffs, procedures)	Internal controls (self regulating groups)
Tall organization chart, autocratic style	Flat organization chart, participative style
Competition, gamesmanship	Collaboration, collegiality
Alienation	Commitment
Low risk-taking	Innovation

Adapted from Trist (1981).

Autonomous work groups. Autonomous work groups bring together individuals with diverse technical and interpersonal skills. The group is usually given decision-making authority and responsibility for task completion. How much latitude a group has in making decisions determines whether it is called "autonomous" or "semi-autonomous."

Proponents of the STS approach argue that the more the key variances--those which "critically affect outcomes" (Cherns, 1978: 65)--can be controlled by the work group, the better the performance of the organization and the higher the satisfaction of its members (Cummings, 1978). For example, if quality problems are a key variance, workers closest to the production process should perform the quality inspections according to STS.

Technological difficulties are easier to solve when a variety of skills are present within the work group. Group members are familiar with the skills and expertise of other members. So, problems can be solved by cooperation. Interpersonal differences may be minimized because of the interaction among work group members.

Autonomous work groups provide another benefit. Because work groups have the authority to make decisions, STS organizations need fewer hierarchical levels than conventional organizations. The internal control mechanisms of the group are substituted for external controls, such as supervisors, specialists, or cost-accounting measures.

Participative style of management. The work group structure necessitates a participative style of decision making. Where possible, decisions are made by workers or with worker input. There may be variation in the weight attached to the worker inputs. But, it is vital to the development of STS that individuals perceive an environment open to their contributions.

Innovation is a byproduct of a participative style of management. Workers often have ideas about how to improve the task and working conditions. If given the opportunity to participate, these ideas may lead to positive changes in the organization.

Commitment. Member commitment is another characteristic of STS. It is encouraged in three ways. First, by enhancing the skills of the employee, the organization may become a more desirable place to work. Second, participation can increase the employee's psychological commitment to the organization (Strauss, 1977). Finally, membership in a small group has been linked to greater individual involvement (e.g. Strauss, 1977).

Sociotechnical Systems Research

Research of STS is difficult. Relatively few firms have implemented structural modifications consistent with STS. Further, the researcher must contend with the high frequency with which these change attempts fail. Trist

found that 98% of the work teams installed by an organization did not survive a decade (1981). While contributing to the difficulty of research, this high failure rate is another reason why study of STS is needed.

The methodology for the study of STS is complicated. For example, since the definitions of, and relationships among the social structure, technical system, and sociotechnical system are not clear, the operationalization of these constructs is an open question.

The major empirical support for STS comes from several important and extensive studies. Four of these studies are reviewed below. The coal mining study was a natural field experiment in which workers attempted to reorganize themselves (Trist et al., 1963). The Ahmedabad experiment (Rice, 1958, 1963; Miller, 1978) and the Shell, Ltd. study (Hill, 1971; Burden, 1975) examined STS interventions. Walton's study of the Topeka pet food plant involved a plant start-up (1972, 1975, 1977).

The coal mining studies. Trist and his associates studied English coal mining operations (Trist and Bamforth, 1951; Trist et al., 1963). Using on-site observations and informant interviews, they compared the effects of three different production systems.

Coal mining is relatively simple. It requires the performance of three jobs: (1) preparation of the mine face; (2) extraction and transportation of the coal; (3)

advancement of the equipment and structural supports into the mine. In the traditional method of coal extraction, miners worked alone or in pairs. Each miner was trained to perform several tasks. Workers were usually highly skilled craftsmen and the pairs often remained partners for life.

The conventional longwall method of coal extraction developed as the technology changed. This method is based on the principle of narrow task specialization, one man-one job. Workers performed one task and expected to spend "all or most of their underground life in this one occupation" (Trist and Bamforth, 1951: 19). A complete cycle of prepare, extract, and advance was done in 24 hours. Only one task was performed during an eight-hour shift, i.e. workers assigned to the extract crew did only that job during their shift. The interdependence of the three major tasks was a serious problem. If performance at any stage was not completed, later stages could not be performed. Cooperation was essential to task performance under this production system. But, cooperation was complicated by the temporal segregation of the tasks.

An alternative to the conventional longwall approach, consistent with STS, was called composite longwall. The work shift consisted of six to eight multi-skilled men. They worked one section of the face and continued their production cycle from the previous day's stopping point. Larger groups developed their own methods of task assignment and shift rotation. The rotation and assignment systems

promoted skill variety and employee versatility. Key variances were resolved as work teams modified their production systems (primarily job rotation) to meet the changes in the technological and work environments.

The researchers concluded that changing from a conventional to a composite longwall system resulted in higher group cohesion, lower job stress, lower incidences of burn-out, higher satisfaction, lower absenteeism and higher productivity. (See Table 3.)

The textile mills. An experimental reorganization consisting of the formation of semi-autonomous work groups was studied at the Calico Textile Mills in Ahmedabad, India (Rice, 1958, 1963; Miller, 1978). The first experiments were conducted in weaving sheds with 224 automatic looms. Three major activities had to be performed in the shed: 1) prepare the loom for weaving, 2) weave, an activity performed by the machine, and 3) unload the cloth from the loom. During the weaving stage a bobbin carried the thread through the loom. The machine automatically replaced the empty bobbin. An operator had to be available to repair thread entanglements and breakage. The normal time for repairing minor difficulties was 30-60 seconds. A major entanglement or breakage of many threads could result in down-time in excess of 60 minutes. Routine maintenance activities were performed during the preparation and unloading stages.

Table 3

Absenteeism and Productivity Rates
Coal Mines

	Conventional Longwall	Composite Longwall
Percentage of time spent reworking tasks done poorly by other shifts	25%	5%
Absence rate percentage	20%	8%
Productivity as a percentage of ideal productivity (perfect efficiency in getting out coal)	78%	95%

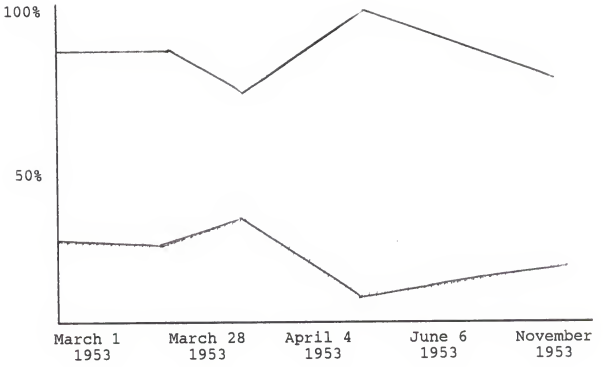
Adapted from Trist and Bamforth (1951).

Twenty-nine workers manned the 224 looms. Eleven of the 29 were weavers, responsible for monitoring and repairing the looms during the weaving stage. Eleven workers performed the preparing and unloading tasks. Maintenance was conducted by seven individuals, each with a specific area of expertise. A single supervisor was responsible for the entire shed.

Before the experiment individuals were permanently assigned to specific tasks. Despite the interdependence of the tasks, there seemed to be no stable internal work groups (Rice, 1958). Individual weavers did not consistently work with particular maintenance crews, nor were workers consistently assigned to specific looms.

Management decided to implement semi-autonomous work groups on one block of looms. They found the spontaneous acceptance and formation of the work groups by the workers surprising (Rice, 1958: 70). Four groups started work on March 30, 1953. Each group consisted of 4 weavers and 3 set-up and maintenance workers. Fifty-nine days later, June 6, 1953, the rest of the shed was reorganized in this manner.

After the implementation of semi-autonomous work groups, efficiency increased. (See Figure 2.) However, performance dropped after approximately eight months (November 1983). The semi-autonomous work groups had to contend with many difficulties. Investigators found that training new workers in the new methods had been neglected. There



Adapted from Rice (1958)

Figure 2

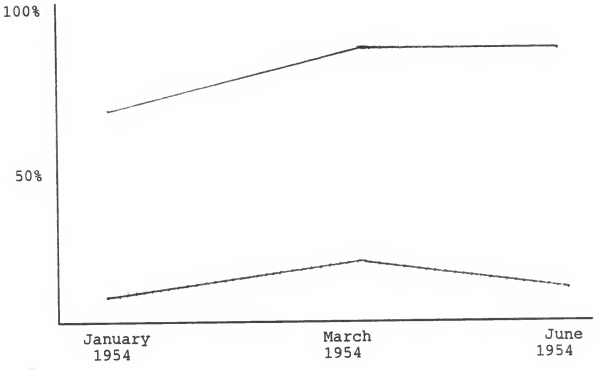
Efficiency and Damage Percentages
Automatic Looms

were not enough workers. Group leaders didn't have enough time to lead. So, group members regressed to pre-experimental work habits. A new pay system and training program were implemented to correct the problems. Recovery was rapid.

In an experimental shed consisting of non-automatic looms, similar success was initially obtained. In the non-automatic process the loom stops when the bobbin is empty. An operator must replace the bobbin. Replacement takes 20 seconds and must be done every 3-12 minutes depending on the type of cloth being woven and the capacity of the bobbin. Each weaver was responsible for two looms. The operator reported to a maintenance worker who oversaw 40 looms.

Semi-autonomous work groups were formed in the shed. Eight workers were responsible for 24 looms during their shift. Under the conventional system, this work required 22 individuals. The implementation occurred in January, 1954. By the end of March, workers and supervisors agreed to increase the size of a work team from 8 to 11. The eight-member work teams were unable to perform the jobs.

The pattern of change in damage and efficiency percentages is similar to the pattern of change in the automatic loom sheds. (See Figure 3.) After a very slow start, the efficiency of the non-automatic shed climbed steadily until it surpassed the equivalent efficiencies in other sheds. The quality of the cloth improved until it too was



Adapted from Rice (1958)

Figure 3

Efficiency and Damage Percentages
Non-Automatic Looms

better than the standard achieved in other sheds (Rice, 1958: 166).

After six years the production levels had been successfully maintained in one of the experimental settings (Rice, 1963). Group members valued cooperation. The workers felt that they had higher status than those in traditionally organized loom sheds. They also felt that pay bound them to the group. One major shortcoming of the new system was the common belief that work in the group system was so hard that it shortened life.

In other experimental settings the results were not as encouraging. Group members did not consider group performance their responsibility. Many supervisors assumed that poor performance could only be remedied by intensive supervision. These methods of supervision undermined the authority of the group leader and sabotaged the possibility for group accountability.

Individuals regressed to pre-experimental work patterns in other sheds. Perhaps because of supervisor arbitrariness or the relative impotence of group leaders, union representatives served as an alternate channel of communication between the work group and management. Workers spoke of having to "carry" fellow group members who were slow, old, lazy, or troublesome. They were reluctant to criticize unproductive group members. Despite complaints of diminishing team spirit, group identification remained high (Rice, 1963; Miller, 1978).

The Topeka plant. A third important study of an STS implementation was done at the General Foods dog food plant in Topeka, Kansas (Walton 1972, 1975, 1977). The operations of the plant were designed to make the jobs challenging and meaningful. To this end, work in the plant was organized around autonomous work groups. Three processing teams and three packaging teams were used. One processing team and one packaging team worked on each of the plant's three shifts. The teams were composed of a team leader and from 7 to 17 operatives. This size was selected to be large enough to include a number of interrelated tasks and small enough to allow ease in decision-making and coordination.

Teams had autonomy for individual job assignments, but no individual was permanently assigned to a particular job. Maintenance, quality control, custodial services, industrial engineering, and personnel activities were performed by the operatives.

Schrank (1974) found high levels of worker participation, freedom to communicate, expressions of warmth, and commitment in the Topeka plant. Lawler, Jenkins, and Herline found similar evidence in another study of the site (1974). According to Lawler, "Our data . . . show high levels of satisfaction and involvement in all parts of the organization. In fact, they show the highest levels we have found in any organization we have sampled. I specifically compared it with other small organizations and still found it superior" (cited in Walton, 1977: 423).

The economic gains in the plant were substantial. "Savings attributable to the work innovations . . . were in the neighborhood of a million dollars annually, a figure significant in a plant with 100 or so personnel and involving a capital investment in the range of 10-15 million dollars" (Walton, 1977: 423).

Shell, U.K.. Another project by the Tavistock group was a study of the Microwax Department in Shell's Stanlow Refinery in Cheshire, U.K. (Hill, 1971; Burden, 1975). A re-evaluation by Shell, U.K. of its corporate philosophy and goals resulted in the conclusion that its social objectives could best be attained through STS.

The transformation to work groups with high worker participation, autonomy, and responsibility was accomplished over a period of three years. Workers took an active part in redesigning the equipment, performing quality testing, and purchasing new equipment. They were given the responsibility to find substitutes when they needed time off. Time clocks were removed. Training proceeded on an individual basis with team members helping to train one another. The implementation of a knowledge-based pay system encouraged skill development.

Morale increased and absenteeism declined in the Microwax Department. The department had a higher promotion rate than the organization. (See Table 4.) Because first line supervisors' power, authority, and knowledge increased,

Table 4

Absenteeism and Promotion Rates
Shell, U.K.

	1963	1964	1965	1966	1967	1968
Absenteeism Rates						
Microwax Department	4.3%	3.5%	3.4%	1.6%	2.1%	2.8%
Stanlow Refinery	4.4%	3.6%	3.8%	3.7%	5.4%	4.0%
	1963	1964	1965	1966	1967	1968
Promotions						
Within Microwax Department	4	2	1	8	9	24
Outside Microwax Department	1	3	9	10	6	13
Percent of Microwax Department Promoted	15.5%	15.5%	31.0%	56.0%	46.5%	115%

Adapted from Burden (1975).

it was possible to eliminate one level of the department's hierarchy. "What was demonstrated was that given responsibility and the requisite authority, senior operators were perfectly capable of running the plant . . . safely and efficiently" (Burden: 207).

Criticism of the Sociotechnical Systems Approach

STS has had at least two constructive effects on research and practice. First, relationships, interactions, and situations at one level of a system are affected by, and affect what happens at other levels. Our understanding of organizations will be incomplete if we continue to focus on a single level of analysis. Second, STS has forced researchers to acknowledge that organizations are "sociotechnical in character" (Hackman, 1981: 77). Organizational life will only be understood when the interdependencies among the technological and social components of an organization are appreciated (Hackman, 1981). Despite the positive results found in research studies, several criticisms of STS have been raised. These concern implementation of autonomous work groups, the atheoretical base of STS, and research at the organization level.

Autonomous work groups. Advocates of STS agree that the social system must fit the technological system. In some circumstances, congruence may best be obtained by use of the traditional, one man-one job, approach. Despite the

recognition of alternatives such as matrix organizations, autonomous work groups seem to be consistently advocated and implemented as the STS answer.

There is some inconsistency between the STS use of groups and what is known empirically about groups (Hackman, 1981). Groups are effective under some circumstances and not others (Maier, 1967). For example, seldom are groups more effective than the most talented individual. Hackman (1981) calls for more knowledge of work teams in organizations, the circumstances in which they are appropriate, and the conditions for their design, installation, and management. He argues that there is a need for models specifying "the factors that are most important in creating conditions for individual, social, and task effectiveness in work teams" (Hackman, 1981: 82).

Atheoretical base. The STS approach consists of a set of organizational design principles which are more like propositions than theoretical statements. Concepts are set out, but great definitional ambiguity exists regarding the crucial dimensions. For example, a key variance can be anything from an environmental contingency to a technological problem. Joint optimization of man and machine is similarly ambiguous. It is not clear what characteristics of the organization are present when optimization is achieved. Also, STS does not explain the relationships among the principles of organizational design. Despite the

intuitive appeal of many STS recommendations, a more coherent theoretical framework which relates the concepts to each other and to other approaches to organizational development should be advanced.

Research at the organization level. STS recognizes the interdependencies of different levels of the organization, but structure is usually conceptualized and assessed at the organization level. For example, the textile mill uses autonomous work groups in its production process. Thus, it is characterized as an STS organization. Non-production departments may be hierarchically organized, but that is inconsequential to the measurement and assessment of the textile mills' "organizational" structure. While STS recognizes the interrelationship between the technological and social systems, STS research is deficient. Study of the system at it's simplest level, the work group, has been largely ignored.

Group Development

The sociotechnical systems (STS) approach makes use of groups but does not consider how their development affects the semi-autonomous work group. One basis for understanding the evolution of a STS is the group development literature. This literature seeks to explain how and why the relations among group members begin, change, and stabilize over time.

A group is defined as two or more people who interact and influence one another (Shaw, 1981). In work groups the members are responsible for the accomplishment of the task and must fulfill the expectations of the organization. They are guided by the goals of the group and by the goals of the organization (Heinen and Jacobson, 1976).

Group development models which describe sequential stages through which the group passes on its way to maturity have been advanced by Tuckman (1965), Bales (1953), Bales and Strodtbeck (1951), Heinicke and Bales (1953), Schroeder and Harvey (1963), Olmsted (1962), Modlin and Faris (1956), and Jacobson (1956). Concepts from these approaches are integrated into the general model discussed below. There are four stages in the integrated model:

Stage 1- Orientation

Stage 2- Conflict

Stage 3- Cohesiveness

Stage 4- Maturation

These labels correspond to the dominant process which occurs during the phase.

Orientation

The first stage in group development is orientation. Individuals begin to identify with the group. They analyze their relationship in terms of what can be gained from group interaction, whether a contribution to the group can be

made, and whether there is congruence between their personal goals and the needs of the group (Jacobson, 1956).

The new group begins as an undifferentiated collection of individuals (Schroeder and Harvey, 1963). Group members must identify the requirements of the task and the processes of group interaction. In a work organization, the technology, structural interdependence, and division of labor limit group activity. However, while task definitions may be clear, "group boundaries are poorly defined and the set of expectations about reciprocal behavior is not clearly explicated" (Heinen and Jacobson, 1976: 104).

Members must discover the "ground rules" of the group. They must identify behaviors which are acceptable to the other group members. During the orientation phase, group members refrain from challenging the leader (Bennis and Shepard, 1956). They hope that the leader holds the "grand plan that contains the 'rules of the game'" (Perkins, Neiva, and Lawler, 1983: 21). Other sources of guidance are informal leaders and accepted industry practice.

Conflict

The second stage of group development is conflict. This is a highly emotional and hostile period. Interactions within the work group are inconsistent and infighting is common. Low group consensus and cohesiveness are characteristics of this phase (Tuckman, 1965).

"Key issues" divide the group. They usually concern uncertainty over interpersonal development. Differentiation of group structure begins (Jacobson, 1956; Olmsted, 1962; Schroeder and Harvey, 1963). Subgroups proliferate and there is a resulting decrease in the cohesiveness of the group (Heinen and Jacobson, 1976).

Conflict and hostility may be directed at the leader. If this occurs, the conflict will end when the leader is challenged and rejected by all group members. In an organizational setting where the supervisor is appointed, challenges can be made to the leader's power and authority but complete rejection is unlikely.

Cohesiveness

The third group development stage is cohesiveness. The processes of the conflict stage are reversed and integration is emphasized. Group members want to maintain interpersonal relationships (Schroeder and Harvey, 1963). They avoid tension to preserve solidarity (Bennis and Shepard, 1956). "The struggles of stage 2 have given members a sense of 'having arrived' as a group" (Heinen and Jacobson, 1976: 105).

The group becomes an entity as the group members accept both the group and their fellow members. The group establishes norms which will insure its existence. It develops a strong resistance to external threats. "Harmony is of

maximum importance, and task conflicts are avoided to insure harmony" (Tuckman, 1965: 386).

Maturation

The final developmental phase is maturation. The group, which established its viability in the cohesiveness stage, becomes an "effective, problem solving, well-integrated group" (Heinen and Jacobson, 1976: 105). It can deal with complexity, disagreement, and obstacles in innovative ways (Tuckman, 1965).

Since the subjective relationships have been established, group members can adopt roles which will enhance the task performance of the group. Individuals understand their role with respect to group function (Tuckman, 1965). Worker skills and expertise are common knowledge. The group can utilize the skills of the members to respond to external demands. Maximum performance levels are attainable.

The concept of group maturity is not well defined. Some theorists draw similarities between group maturity and individual maturity (Bennis and Shepard, 1956). The mature group knows very well what it is doing. It has the ability to develop a stable structure while maintaining the capacity to adapt to a changing environment (Heinen and Jacobson, 1976).

The Research

The focus of this dissertation is on the extent to which the structure within a semi-autonomous work group is

influenced by the unit technology and the worker characteristics. Proponents of STS argue that both the manufacturing characteristics (the technical system) and personal dimensions (the social system) influence the development of the social structure (the STS). Several empirical questions remain. Is the social structure a function of both task and worker characteristics? Does the social structure remain stable over time? Do the worker and task characteristics which affect the social structure shift in importance over time?

Group development theorists have ignored the effects of technical constraints on group evolution. Yet, these technological characteristics may have a dramatic effect on the developmental stages. If task performance is the priority of the organization, group members may give little time or attention to the resolution of problems in the different stages. Another question then is whether or not autonomous work groups progress through the stages of group development?

Finally, the effect of social structure on organizationally relevant outcomes was examined. Does the social structure of the work group affect group performance? Is individual performance a function of social structure? Does structure have an impact on individual satisfaction?

Propositions

Seven propositions were formulated to assess certain aspects of the research questions. Each is discussed in detail.

Relationship between technological factors, personal characteristics and social structure. The first set of propositions concerns the effect of personal characteristics and technological factors on the emerging social structure. The basic premise of the proposition is that as the technological demands increase and the accompanying production demands become more coercive, the social structure will become increasingly dictated by technological factors. This premise is supported by the research regarding the technological imperative (e.g. Fry, 1982).

Interpersonal attraction is based on the similarity of individuals with respect to salient personal characteristics. When behavioral flexibility is high, as suggested by the shaded portion of Figure 1, individuals can seek others on the basis of these characteristics. As technological constraints increase, individuals will have less time and energy available to locate others similar to themselves. They will be more likely to interact with others on the basis of technological factors. Thus:

P_1: At time 1, structural subgroups will demonstrate

homogeneity with respect to personal characteristics: They will be less homogeneous with respect to technological factors.

P_2: At time 2, structural subgroups will be moderately homogenous with respect to both personal characteristics and technological factors.

P_3: At time 3, structural subgroups will be less homogeneous with respect to personal characteristics: They will be more homogeneous with respect to technological factors.

Relationship between stages of group development and autonomous work groups. Although ignored by STS, the group development literature may provide an explanation of some of the phenomena that occur during the evolution of autonomous work groups. Since the conflict stage (2) is characterized by infighting and hostility, the number of structural subgroups and the level of group cohesiveness can be used to identify this phase. The number of subgroups within the work team should be low during the orientation stage (1), high during the conflict stage (2), and low during the cohesiveness stage (3). Group cohesiveness follows the reverse path. During the conflict stage (2), group cohesiveness should be low. The orientation stage (1) and cohesiveness stage (3) should be times of high cohesiveness. It is therefore hypothesized that:

P_4: The number of subgroups within a work group will exhibit a concave pattern over time.

P_5: The level of group cohesiveness within a work group will exhibit a convex pattern over time.

Relationship between structure and outcomes. Both the group development literature and advocates of STS contend that effective performance is a desirable and expected outcome. Structural characteristics such as the overlap between the production and social communication matrices and the amount of stability in the structure should be related to either group or individual performance. Because there is little research in this area, the direction of the relationship is not known.

P_6: Structural characteristics of work groups will be related to both individual and group measures of performance.

Proponents of STS contend that satisfaction is another outcome of a work group implementation. Higher satisfaction may be related to the task characteristics themselves (e.g. Hackman, Oldham, Janson, and Purdy, 1975). However, STS argues social structure is also a predictor of job satisfaction.

P_7: The structural relationships of an individual will be related to his or her job satisfaction.

Summary

Chapter 1 presents the theoretical foundation, research questions and propositions which will be examined in this dissertation. A summary of the propositions is presented in Table 5. STS has been used in a number of organizations, despite some contradictory evidence as to its long-term effects. The implementation of autonomous work groups is a principle characteristic of the approach. Certain developmental processes which must occur within autonomous work groups may be constrained by the technological environment. Propositions relating the social structure to technological and interpersonal variables, to performance, and to job satisfaction were proposed. Additionally, propositions concerning work group development were suggested.

Table 5

Summary of Propositions

P_1:	At time 1, structural subgroups will demonstrate homogeneity with respect to personal characteristics: They will be less homogeneous with respect to technological factors.
P_2:	At time 2, structural subgroups will be moderately homogenous with respect to both personal characteristics and technological factors.
P_3:	At time 3, structural subgroups will be less homogeneous with respect to personal characteristics: They will be more homogeneous with respect to technological factors.
P_4:	The number of subgroups within a work group will exhibit a concave pattern over time.
P_5:	The level of group cohesiveness within a work group will exhibit a convex pattern over time.
P_6:	Structural characteristics of work groups will be related to both individual and group measures of performance.
P_7:	The structural relationships of an individual will be related to his or her job satisfaction.

CHAPTER II

THE RESEARCH SETTING AND STRATEGY

The development of semi-autonomous work groups in a new organization was studied at a plant which was designed, constructed, and staffed with sociotechnical systems (STS) principles in mind. Employee "fit" with the semi-autonomous work group characteristics of participation and team work was considered in the hiring of hourly workers. Management planned the start-up to ease worker adaptation to the new organization and technology.

Research Setting

The Smithton plant is located in a Southeastern college town. It is one of the company's four manufacturing facilities. The company is a wholly owned subsidiary of a major corporation in the beverage industry. It manufactures cans and ecological (one piece) lids. Smithton manufactures ecological lids only.

The Smithton plant began operating in December 1982 with a single production line (module). In April 1983, the equipment for a second module was completely installed and production began. In August 1983, continuous production started in the third module.

Workers had a difficult task. There was pressure to meet production goals but the prototypic equipment, designed especially for the plant, caused unexpected technical problems. Because of the difficulties associated with meeting the production goals, the budget of 47 million lids established by the plant manager in December 1982 was reduced to 41 million lids in April 1983 and then to 40 million lids four months later. The hourly workers were not told about the budget decreases. Specific production goals were announced in August 1983 and a plan was developed to reach the targets.

Quality is a critical factor in the manufacture of lids. Narrow production tolerances must be met. Scoring, the opening lines etched into the lid, is a constant source of difficulty. If the scoring is not deep enough, the lid will not open. However, if the scoring is too deep, the pressurized contents of the filled can will leak. In the early phase of operation, the use of railway transportation added to the quality problems. Lids that appeared to be strong weakened and leaked after the filled can had been shipped long distances.

Because Smithton was not the sole supplier of lids for the company, producing a quality product was crucial to its viability. Smithton was required to repurchase the containers if the lids were unacceptable to the customer. However, this cost was slight compared with the decreased revenues

Smithton could sustain if it acquired a reputation for poor quality.

The Technical System

Several aspects of the technical system will be discussed including the structure of the organization, schedule of operations, production equipment, task assignment, job rotation, and production.

Structure of the organization. At full capacity, there were four semi-autonomous work groups at Smithton. Each team consisted of 22 hourly employees and a superintendent. The teams worked as shift crews, i.e. one team staffed the plant during a shift. The four teams, A, B, C, and D, were created in January 1983 with 14 operatives and a superintendent. By August 1983, each team had 18 members. Full staffing (22 members) was achieved by December 1983.

Team members were urged to accept personal responsibility for the operation and maintenance of equipment and for the quality of the output on their shifts. Teams were encouraged to work as a unit in looking for equipment problems and solutions, helping to cross-train other team members, and producing high quality lids.

The management structure is shown in Figure 4. Each team was under the direction of a superintendent, a salaried managerial employee. Each superintendent was permanently assigned to a specific work group. The superintendents had

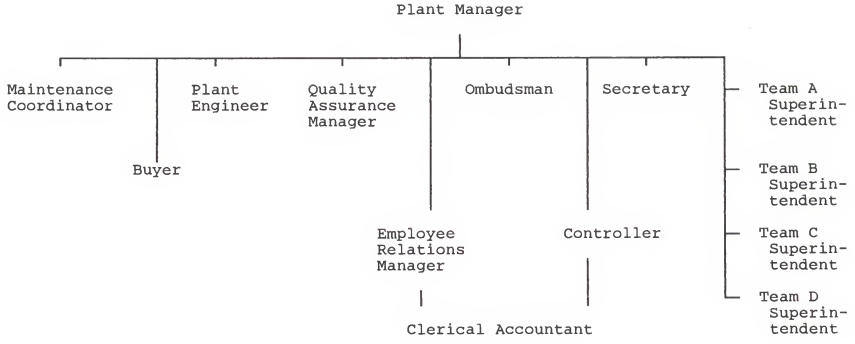


Figure 4

Management Structure

previous experience in the industry. They reported to the plant manager.

A team leader assisted each superintendent. The team leader, an hourly employee selected by the managerial staff, was highly skilled and possessed a working knowledge of all the equipment. Team leaders had responsibilities above those of other hourly workers and usually served as record keepers. Further, they were responsible for team management in the absence of the superintendent. The team leader received a small wage differential.

Support personnel included an employee relations manager, a quality assurance engineer, a maintenance coordinator, and an ombudsman. A flat organizational structure was utilized because of the semi-autonomous work groups. According to informants, there were fewer support personnel and one less managerial level at the plant than was the industry norm.

Schedule of operations. The plant operated 24 hours a day, seven days a week. The normal shift was 12 hours long. Each team worked three days (or nights), then had three days (or nights) off. Sister teams worked the same three days and had the same three days off. The A and B teams were sister teams as were the C and D teams. Table 6 illustrates the shift arrangement. Every four months, the day shift rotated to the night shift and vice versa. This was a

Table 6

Operational Schedule Example

	Shift	
	6:00am-6:00pm	6:00pm-6:00am
Monday	Team A	Team B
Tuesday	Team A	Team B
Wednesday	Team A	Team B
Thursday	Team C	Team D
Friday	Team C	Team D
Saturday	Team C	Team D
Sunday	Team A	Team B
Monday	Team A	Team B
Tuesday	Team A	Team B
Wednesday	Team C	Team D

variation of the general arrangement for shifts in this industry.

Shifts did not overlap. One team was scheduled to leave at 6:00 and another team scheduled to arrive at that time. Most employees knew each other from informal meetings at the plant, working overtime together, and attending training classes together.

Since production was continuous, certain tasks had to be constantly performed and certain machines continuously monitored. Team members spontaneously worked out their own informal relief system so they could take breaks. Employees were allowed four ten-minute rest breaks and a twenty-minute lunch break. One team modified this schedule and created two twenty-minute breaks and the lunch break.

Equipment. The production process was quite involved. Figure 5 shows the layout of a single module. The plant had three production modules when the study was completed. A fourth module was added later.

A large coil of aluminum fed the shellpress from the rear. With each stroke, the press cut out rounds and bent the edges slightly. The press in the first production module cut 16 shells per stroke at 105 strokes per minute. The presses in the second and third modules cut 20 shells per stroke at 120 strokes per minute.

After the shells were cut and slightly curled, they moved on a conveyor belt to the curlers. The curler spun

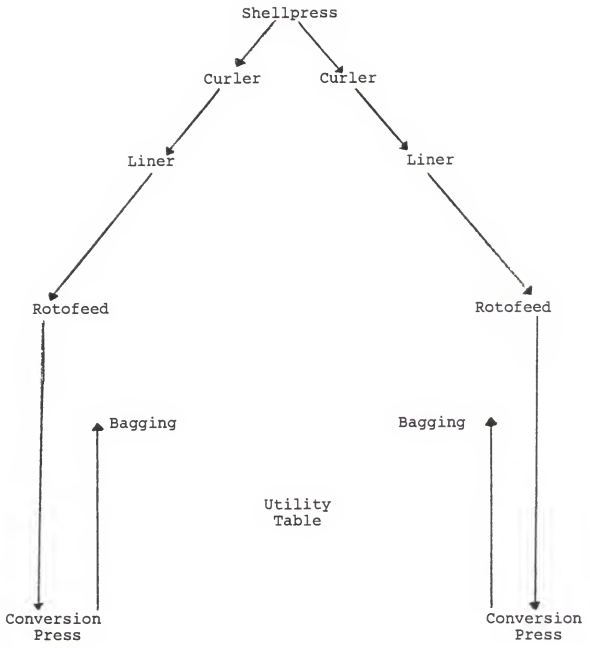


Figure 5

Production Equipment Layout

very fast and twisted the edges of the shell to the desired specification. There were two curlers for each shell press. They were located about three feet from the shell press, one on each side.

A conveying belt transferred the shells from the curlers to the liners. The liner applied a compound to the shells which acted as a gasket and sealed the lid to the can. Very rigid specifications with respect to the composition and amount of compound were required. Although the compound was nontoxic, the liquid in the can could become cloudy if too much compound was put on the shell. If too little compound was used, leakage could occur.

Another conveying system took the lined shells to the rotofeeds. The rotofeed served as an inventory device. The machine consisted of 20 metal columns, each 3 feet high. Automatic machinery placed stacks of shells in the columns. The columns rotated and fed the conveying system to the later equipment. This conveying system was twenty feet long and moved the shells at a height of about seven feet.

The final stage of manufacturing was the conversion press. The conversion press scored the lid and attached the opening tab. Unfinished lids went in through the sides of the press to have phrases such as "Pitch In" and other required codes cut into them. Simultaneously, the aluminum for the tabs was fed into the front of the press. Various dies cut out the tab as the stock moved through the machine. In the final procedure, the completed tab and lid were

joined. The conversion press produced 800 finished lids per minute.

The lids moved out of the conversion press and were placed in long narrow paper bags by workers. Each bag contained 400 lids. The workers stacked the full bags on a wooden pallet. Completed pallets (330 bags) were wrapped and taken to the warehouse.

Tasks. Individuals were assigned to work with a particular machine or on a specific task during their 12-hour shift. Although there were some simple, routine tasks, employees at even the lowest skill level had jobs with several duties. For example, some positions required the employee to design additions to the equipment.

When the first module became operational, the positions to be staffed included:

Shellpress (1 operative)

Liner (2 operatives)

Rotofeed (2 operatives)

Conversion Press (2 operatives)

Bagging (2 operatives)

Quality Assurance (2-3 operatives)

The shellpress and liner operators shared responsibility for curler maintenance.

In April 1983, one production module was in operation and each of the four work teams consisted of its permanent members plus several temporaries. The temporaries were

assigned simple tasks, such as restacking uncompleted pallets. The team leader was a working member of the team and had a specific assignment. As the prototypic machine problems decreased and additional modules were added, evolution of the job assignments occurred. For instance, a single conversion press operator worked both machines within the module. The liner and rotofeed assignments were originally performed by one operative. Later this practice changed. The shellpress operator acquired responsibility for the liner and the baggers took over the rotofeeds.

All teams had a utility person. This individual cleaned the plant and break rooms, provided supplies and removed completed pallets from the plant to the warehouse.

Several teams used a "floater." The floater, usually an operator who could perform a variety of tasks, worked with spot problems and relieved employees for breaks. On some teams, a floater was selected for each module. On others, one floater worked plant-wide.

In June 1983, management changed the structure of the module assignments. They required the teams to employ four-person modules staffed in the following manner:

Shellpress (1 operative)

Conversion Press (1 operative)

Bagging (2 operatives)

Although this was initially a difficult staffing pattern to implement, the four-person module was adopted by all teams. Workers not assigned to modules were used in the machine

shop, store room, warehouse, or quality assurance lab. Special assignments involving electrical systems, mechanical parts, employee training, or off-site quality assurance checks became common.

Job rotation. The plant management discouraged permanent job assignments and encouraged job rotation. Besides the machine assignments, employees rotated through the machine shop, store room, quality assurance lab, and other special assignments. The quality assurance rotation was unusual for the industry. This position was usually a specialized task separate from production.

Job rotation was constrained by individual characteristics and situational factors. An individual could not be assigned to particular tasks until he or she had the necessary skills. Skill development was accomplished formally through training classes, and informally through on-the-job training by co-workers and superintendents. Situational factors which limited rotation included the production emphasis and availability of training.

Although there was a strong and continuing overt commitment to job rotation, the actual incidence of job rotation decreased during the study period. A job rotation index was constructed using assignment matrices completed by a researcher-observer. (See Appendix A.) The observer systematically visited Smithton over the study period. Each time she visited, individual task assignments were recorded.

A job rotation matrix was constructed from these assignment matrices by aggregating the job changes of an individual. (See Figure 6.) If the individual moved "from" shellpress "to" conversion press, an entry was made in the appropriate off-diagonal cell (A). If the next observation indicated the he or she remained at the conversion press, an entry was made in the on-diagonal cell (B). The job rotation index was the percentage of changed assignments (off-diagonal cell entries) given the total number of assignments (all cell entries) for the four-month interim periods. Figure 7 shows the levels of assignment rotation over the study period.

Production. The increase in production over the 18 months of the study is shown in Figure 8. The production level is the average shift production for the four months ending at the specified date. Although production varied by work team, the overall plant trend showed a steady increase, leveling in April 1984.

The Social System

To understand a social system "rigorous attention must be paid to occupational roles and their structure, methods of payment, [and] the supervisory relationship[s]" (Trist, 1981: 36). To understand occupational roles in the site, it is useful to discuss the selection procedure, the skill-based method of payment, and employee demographic

TO:	FROM: Shell Press	Liner	Roto-Feed	Conversion Press	Quality Assurance	Utility	Other
Shell Press							
Liner							
Rotofeed							
Conversion Press	A			B			
Quality Assurance							
Utility							
Other							

Figure 6

Job Rotation Matrix

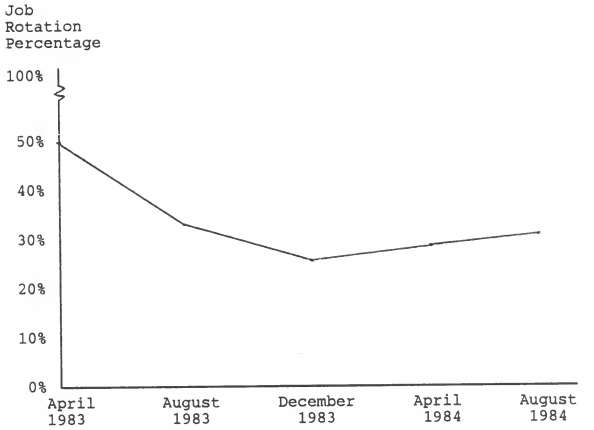


Figure 7

Job Rotation

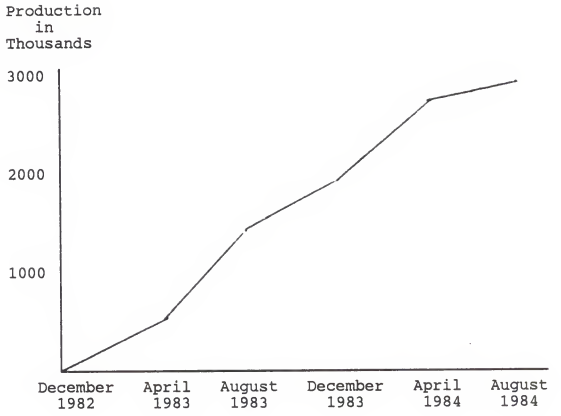


Figure 8

Average Plant Production per 12-Hour Shift
Four Month Intervals

characteristics. The role of the supervisor in the semi-autonomous work group was discussed earlier.

Selection. Selection at the Smithton plant differed from the approach used in most manufacturing plants. Selection criteria are usually limited to skill tests and interviews administered by the personnel department. At Smithton all applicants were screened through interviews designed to assess technical ability or technical potential. Individuals with the requisite skills were required to attend a 42-hour course at a local community college. Smithton designed the course which included instruction in blueprint reading, mathematics, safety, and mechanical design and repair. Applicants attended the class on their own time and received no pay. Subject matter testing was done during the course and the scores used in the selection decision.

Those who successfully completed the community college course were interviewed by at least seven staff members. The four superintendents always participated in these interviews. Each interview lasted an hour and attempted to assess the applicant's technical and interpersonal skills. No interview protocol was established. Staff members looked for initiative, good communication skills, the ability to work without direct supervision, a sense of organizational commitment, and the ability to work within a semi-autonomous work group.

Specific selection criteria were never formally adopted. Selection was done by consensus. Staff meetings were held periodically and each applicant was discussed before hiring decisions were made.

When a person was selected, the employment offer was made by the plant manager to the applicant and his or her spouse. A realistic job preview was given to both parties. It included both the positive aspects (high quality of work life and participative management) and negative aspects (demanding schedule and required training) of the job.

A variety of skills were present in the work force. Some individuals were highly trained, i.e. electricians, mechanics, welders, and hydraulics experts. Others had little or no industrial experience or skills. However, these individuals were judged to have high technical potential. Subjects were assigned to teams with the goal of skill balancing the work groups.

Skill development. Management planned for workers to be cross-trained. This would facilitate skill development and job rotation in accordance with STS. A skill-based pay system was used to stimulate individual development. The pay scale and skill steps are presented in Table 7. The steps are numbered as one would proceed up the promotion ladder. Skills were assessed upon entry and the worker was assigned to the appropriate pay level. Team superintendents performed the promotion evaluations. Management hoped that

Table 7

Base Wage Progression Steps

Plant Job Classification	Entry Rate	First Progression	Second Progression	Third Progression	Fourth Progression
Maintainer/ Plant Technician	$12.83 (11)	$13.19 (12)	$13.55 (13)		
Maintainer/ Production Technician	$12.30 (6)	$12.54 (7)	$12.78 (8)	$13.02 (9)	$13.26 (10)
Maintainer/ Production Technician Trainee	$11.13 (1)	$11.31 (2)	$11.49 (3)	$11.67 (4)	$11.85 (5)

A shift premium of $.20 per hour is added to the base rate for employees working the night shift.

all workers would eventually possess all the skills required for operation of all the machinery.

Operative characteristics. The eighty-eight hourly employees and their superintendents are the subjects of this research.

The demographic characteristics of the groups are presented in Table 8. The average age of the subjects was 32.6 years. The majority of the subjects was male (89%). Each team had two or three female members. Seventy-two percent (72%) of the subjects were married. This characteristic exhibited the greatest variance across work teams ranging from 80% (Team A) to 63% (Team D). Subjects had, on the average, the equivalent of some technical school experience. All subjects had a high school diploma. Team A members had the equivalent of a technical school degree. There was no significant difference in entry skill level between the teams. Only four of the hourly employees had experience in the lid industry before coming to Smithton.

Sociotechnical Systems Principles

The plant was designed to differ both technically and philosophically from other manufacturing concerns in the company and the industry. Similar equipment had been used in the industry, but all the equipment for this plant was specifically designed. It was high speed, highly automated,

Table 8

Operative Demographic Characteristics

	Team A	Team B	Team C	Team D	Overall Mean
Age	33.1	32.6	31.2	33.6	32.6
Sex (% Male)	90%	90%	86%	89%	89%
Marital Status (% Married)	80%	76%	68%	63%	72%
Education	5.0	4.4	4.5	4.9	4.7
Entry Skill Level	5.0	5.3	4.8	5.3	5.1

and highly integrated with a planned capacity which exceeded industry levels at the time it was built.

Participation. Worker participation in decision making, ranging from nominal opinion giving to total autonomy, was initially encouraged. Management expected employees to suggest improvements, find solutions, and otherwise participate in the plant's operation.

The plant atmosphere was informal. Although formal lines of authority were defined, the dominant modes of communication were informal. The plant manager put emphasis on the fact that all were equal within the plant. Production employees and staff workers used a single cafeteria/break room. The conference room had a round table, signifying no "head" person.

Management wanted to foster and maintain a climate of trust and honesty. Workers were given discretion in performance. They were trusted to complete their own time cards.

Each team had an informal meeting just before the work day started. Workers were not paid to attend the meetings and attendance was not required, however most employees attended. The meetings lasted approximately fifteen minutes.

Innovation was encouraged and workers were free to make design changes to modify the equipment as needed. Management wanted employees to have a "license to fail." They hoped that equipment failures and design problems would be

studied to determine appropriate prevention and correction techniques.

Innovation and implementation. STS was planned and implemented by three key actors; one corporate officer, the plant manager, and the plant employee relations manager. According to informants with previous industry experience, the management philosophy at Smithton was unique. The industry was generally characterized by directive management, highly specialized tasks, low employee involvement, and unionization. At Smithton the work force was non-unionized, employee involvement was high, and the managerial style was non-directive. Managers hoped that employee commitment would follow.

Research Strategy

The study is a natural field study. Field studies deal with "intact, naturally occurring systems as opposed to those created for research purposes" (Stone, 1976: 130). Independent variables are not manipulated by the researcher. There are two advantages of a field study research strategy (Stone, 1976). First, field studies are very realistic because they are conducted in natural settings. Second, complex phenomena can be studied more readily than in a laboratory setting. It is difficult to manipulate complex and interdependent situational factors in a laboratory environment.

Hypotheses

The propositions, presented in Chapter I, were specified as hypotheses which could be tested. The first three propositions (Table 5) suggest a relationship between technological factors, personal characteristics, and the sociotechnical structure of work groups. The structure of the work teams was approximated by the communication-based structural subgroups. Tichy (1981) argues that cliques derived from this type of relational data are an improvement over more traditional structural assessment techniques such as asking individuals to what group they belong. Network analysis bridges the gap between macro- and micro-level analyses of organizational processes (Crozier, 1972). Individuals provide sociometric data, but network analysis pieces it together to determine the larger structure.

Two variables were used as personal characteristics, age and work as a central life interest. Age was used because it is a simple surrogate for a number of personal characteristics such as marital status, educational level, and life stage (e.g. Levinson, 1977). Further, there is evidence that age itself is a basis for interpersonal attraction (Lott and Lott, 1965).

Work as a central life interest is a measure of the general importance of work to an individual. It was selected because of its high salience in this work setting. The salience of a characteristic affects the likelihood that it will be the basis for interpersonal attraction (Tversky,

1977). During the selection process and socialization processes, emphasis was placed on a high need for achievement and a positive attitude toward work and toward the company. This strong emphasis by management on these concepts should make them highly salient to the new employees.

Two variables were used as technological factors. These variables are 1) an individual's task assignment and 2) his or her module assignment. The equipment with which one works, as well as the production line on which one works should affect his or her position in the STS.

The following hypotheses were used to examined P_1, P_2, and P_3:

H_1: At time 1, structural subgroups will demonstrate homogeneity with respect to personal characteristics, age and work as a central life interest: They will be less homogeneous with respect to technological factors, task and module assignment.

H_2: At time 2, structural subgroups will demonstrate moderate homogeneity with respect to personal characteristics, age and work as a central life interest, and technological factors, task and module assignment.

H_3: At time 3, structural subgroups will demonstrate less homogeneity with respect to personal characteristics, age and work as a central life interest: They will be more homogeneous with respect

to technological factors, task and module assignment.

The next two propositions (P_4 and P_5) explore the relationship between group development stages and autonomous work groups. The hypotheses are based on specific measures of structural subgroups and group cohesiveness. The rationale for the use of these measures is presented in Chapter I.

H_4: The number of structural subgroups within a work group will exhibit a concave pattern over time.

H_5: Group cohesiveness scores will exhibit a convex pattern over time.

Proposition 6 suggests that there is a relationship between group and individual performance and characteristics of the work group structure. Two structural variables were selected to examine the proposition at the group level. One variable is based on the overlap between the patterns of communication for production issues (PIC) and the patterns of communication for social and friendship matters (SFMC). This overlap is a proxy for the congruence between the social system (SFMC) and the technical system (PIC). Research indicates that STS organizations have higher performance than non-STS organizations (e.g. Trist, et al., 1963; Walton, 1975). If this is the case, within a STS the greater the congruence between the social and technical systems the higher the expected performance. Thus:

H_6: The overlap between the production issues communication matrix and the social and friendship

matters communication matrix will be positively correlated with group performance.

The second structural variable concerns the stability of the dyadic relations within a work group. Dyadic stability indicates that an individual consistently interacts with one other individual about technical issues. This may increase the productivity of the group if the individuals are knowledgeable and share information about production issues. On the other hand, if stability is high, the flow of information through the work group may be restricted. Individuals interact with their own group and not with others. Little research has been done in this area. Therefore, the direction of the relationship is not specified.

H_7: The dyadic stability of groups will be correlated with group performance.

The structural variable used for the individual of analysis was the individual's membership in a stable dyad. Membership in a stable dyad was hypothesized to correlate with individual performance. It was further hypothesized that membership in a stable dyad would correlate with individual job satisfaction. Dyadic stability may be positively related to satisfaction if individuals who have a high regard for the work setting are drawn together. Individuals may have high job satisfaction because they perceive a friendly work situation. Alternatively, the dyad could form because members hold similar negative views of work. In this case, dyadic stability would be negatively

related to satisfaction. Because the exact nature of the relationship is not known. the hypotheses do not specify a direction for the correlation.

H_8: Membership in a stable dyad will be correlated with individual performance.

H_9: Membership in a stable dyad will be correlated with individual job satisfaction.

Schedule of Measurement

Data were collected over an 18-month period. The schedule of measurement is shown in Table 9. Age and work as a central life interest were assessed upon organizational entry. This questionnaire was completed by the subjects either in the community college training class or in the plant shortly after the individual began work. Job satisfaction and group cohesiveness were measured in April 1983, August 1983, December 1983, and April 1984. Structural characteristics were assessed through a communication network questionnaire administered in April 1983, August 1983, and March 1984. Individual performance was measured in August 1983. Daily team performance information was available from the records of the organization. The complete scales, which are not copyrighted, and scoring procedures are included in Appendix B. The instruments will be described in Chapter III.

Table 9

Schedule of Measurement

Organizational Entry	April 1983	August 1983	December 1983	March 1984	April 1984
Age					
Work as a Central Life Interest					
	CN	CN		CN	
	GC	GC	GC		GC
	JS	JS	JS		JS
		Individual Performance			

CN- Communication Network, GC- Group Cohesiveness, JS- Job Satisfaction

Subjects were asked to identify themselves on all measures so that they could be tracked over time. Confidentiality was guaranteed by the researcher.

Summary

The research site and strategy were discussed in Chapter II. The plant was designed in accordance with the STS characteristics of participation and semi-autonomous work groups. The social, technical, and sociotechnical systems were described in detail. The hypotheses and schedule of measurement were also discussed. The measures, statistical analyses and results are the subject of Chapter III.

CHAPTER III

MEASURES, STATISTICAL ANALYSES AND RESULTS

The measures, statistical approaches and results will be presented in Chapter III. Research has suggested that individual's misperceive how often, with whom, and about what they communicate (Bernard and Killworth, 1977; Bernard, Killworth and Sailer, 1979/80; Burt, 1980; Killworth and Bernard, 1976, 1979). So, the validity and reliability of the communication measures were assessed first. Then, the hypotheses were tested.

Communication Instrument

A questionnaire was used to gather the communication network data. (See Appendix B.) Each employee was asked to estimate how often he or she communicated, both formally and informally, with all other employees. Responses were based on the Likert scale format listed below:

6- Several times a day

5- Once or twice a day

4- Several times a week

3- Once a week

2- Several times a month

1- Once a month

In the April 1983 and August 1983 administrations, respondents were asked to complete this task for four informational categories; production issues communication (PIC), technical information issues communication, company policy and procedures communication, and social and friendship matters communication (SFMC). Because of the length of the questionnaire, the final administration in March 1984 included only the PIC and SFMC categories. For this study, the PIC and SFMC communication matrices from the three time periods were used.

If the PIC communication matrix is a valid indicator of communication structure, then work teams should emerge as distinct groups from the organization's communication matrix. NEGOPY, a communication network analysis program, was used to perform this test (Richards, 1975: Richards and Rice, 1981). NEGOPY classifies individuals into role categories: group member, liaison, and isolate (Richards, 1975; Richards and Rice, 1981). Group members are defined as a set of three or more individuals who have more than 50% of their interaction with other members of the set. Liaisons have most of their interactions with members of groups or other liaisons. Isolates have few or no links. NEGOPY uses pattern recognition and logical test routines to determine whether the definitional criteria are satisfied.

The results of NEGOPY are presented in Table 10. Three groups emerged in April 1983. Team A and Team B appeared as distinct groups, but Team C and Team D emerged as a single

Table 10

Production Groups Derived by NEGOPY
Percentage of Within Group Linkages

	April 1983	August 1983	March 1984
Team A	85.9%	86.4%	82.0%
Team B	88.7%	85.3%	76.5%
Team C	93.8%[a]	87.2%	89.8%
Team D	93.8%[a]	86.9%	93.0%

[a]NEGOPY derived a single group consisting of Team C and Team D in April 1983.

group. Between 85.9% (Team A) and 93.8% (Team C/Team D combined group) of the total communication took place within the derived groups.

While derivation of the four teams was desired, the combination of Teams C and D into a single group was not a serious concern because they were sister teams. They saw each other before and after their work shifts.

At later periods, the four work teams emerged as distinct communication groups. Table 10 shows the results of the analysis of the August 1983 and March 1984 network data.

The plant manager, ombudsman, and employee relations manager were found to be liaisons between the groups. They had formal communication with the teams through memos and meetings. Also, the atmosphere of the plant facilitated informal communication. The other staff members were isolates.

Because data was elicited for two informational categories, a further assessment of validity can be made by computing the correlation coefficients between (1) the production issues communication (PIC) matrix and (2) the social and friendship matters communication (SFMC) matrix. If respondents differentiated between the information categories represented by the different matrices, the correlations will be low.

The intra-work group matrices were used for this analysis. Squared correlations between PIC and SFMC were

computed and the quadratic assignment procedure (QAP) used to assess the statistical significance of the coefficients.

The QAP test is based on a non-parametric statistic--Hubert's gamma (Γ)--which is distributed as a X^2 (Hubert and Schultz, 1976). The null hypothesis tested by QAP is:

H_o: The rows and columns of the comparison matrix are labeled at random.

The correspondence between the initial and comparison matrices is measured by a raw cross-product statistic (Γ_2: the test Γ). The exact distribution of Γ_o (the null Γ) is obtained from the cross-products of the initial matrix with all possible reorganizations of the comparison matrix. The reorganization of the comparison matrix is based on random relabeling of its rows and columns. If the Γ_t is sufficiently extreme with respect to the permutation distribution, Γ_o, the hypothesis of random relabeling can be rejected and the correlation attributed to causes other than chance (Baker and Hubert, 1981).

The squared correlations are presented in Table 11. Teams A and Team B showed a similar pattern of squared correlation coefficients. Initially low (r^2 = .131 and .142), the coefficients increased over time. In March 1984, Teams A and B had squared correlations of. 535 and .693, respectively. In contrast, the squared correlations for Teams C and D remained relatively constant, ranging from .367 to .489.

Table 11

Squared Correlations between Production Issues and Social and Friendship Matters Communication Matrices

	April 1983	August 1983	March 1984
Team A	.142* (n=14)	.219* (n=18)	.535* (n=21)
Team B	.131* (n=14)	.378* (n=20)	.693* (n=21)
Team C	.465* (n=14)	.489* (n=19)	.372* (n=22)
Team D	.367* (n=14)	.474* (n=18)	.474* (n=22)

*p<.05

In a small work group, individuals were expected to speak with each other about a variety of subjects (Albrecht and Ropp, 1984). Therefore, moderate overlap between PIC and SFMC was anticipated. Despite the significance of the squared correlations, the majority were below .50. The low correlations indicated a divergence between SFMC and PIC networks. They supported the contention that the different communication scales actually assessed different types of communication.

The reliability of the communication networks cannot be assessed using conventional internal reliability formulas, e.g. Cronbach α. An alternative approach to the assessment of reliability uses test-retest correlations. These show the extent to which the instrument yields similar network structures in different time periods.

There are some interpretive problems with test-retest reliabilities. High test-retest reliabilities occur for at least two reasons. First, the instrument may accurately reflect the stability of the communication networks from one time period to the next. Second, a high test-retest reliability could be the result of systematic measurement error. Low test-retest correlations do not mean that the instrument is not reliable. They may reflect true changes in the network structure.

To assess test-retest reliability, a correlation matrix was computed for each work team across the three time periods. The comparison matrices consisted of those

individuals employed at both time periods. QAP was used to test the significance of the coefficients.

The results of the analysis are presented in Table 12. There was no correlation between April 1983 and August 1983 for Teams B or D, nor was there a correlation between the April 1983 and March 1984 communication matrices. A small but non-significant amount of overlap occurred between August 1983 and March 1984.

Team A exhibited the greatest stability. The squared correlation between April 1983 and August 1983 was .524 ($p<.05$). Although declining at the later time points (April 1983/March 1984 $r^2=.239$ and August 1983/March 1984 $r^2=.178$), the coefficients were significant. Team C showed significant squared correlations in the temporally proximal administrations but a non-significant correlation between the more remote communication network administrations.

Assuming the validity of the network instrument, the results suggest that there are different patterns of communication within the semi-autonomous work groups over time.

Hypotheses Tests

This section contains the results of the data analyses performed to test the hypotheses presented in Chapter II. Descriptions of the measures, the statistical tests and the results are presented with the relevant hypotheses. Tests which produced significant results are briefly discussed.

Table 12

Squared Correlation between Production Issues Communication Matrices

	August 1983	March 1984
Team A		
April 1983 (n=14)	.524*	.239*
August 1983 (n=18)		.178*
Team B		
April 1983 (n=13)	.000	.000
August 1983 (n=20)		.050
Team C		
April 1983 (n=13)	.344*	.000
August 1983 (n=17)		.115*
Team D		
April 1983 (n=14)	.000	.000
August 1983 (n=19)		.060

*p<.05

The Relationship between Technological Factors, Personal Characteristics, and Social Structure

The first step in ascertaining the relationship between social structure, technological factors, and personal characteristics was the derivation of the social structure from the work group's production issues communication (PIC) matrix.

The structure of the work teams was established using the UCLUS procedure, a hierarchical clustering technique (D'Andrade, 1978). UCLUS is based on the U-statistic, a non-parametric measure of association (Seigel, 1956). The analysis begins with a cluster list consisting of the original individuals. To ascertain which two clusters are closest, one determines whether a randomly drawn distance measurement from one pair of clusters is likely to be less than a randomly drawn distance measure from another pair of clusters. The closest two clusters are merged and the old pairs removed from the list. Ties between two different pairs of clusters are broken by selecting the pair of clusters which have the least distant pair of original objects. Clusters are printed out at each merger. Also printed is the lowest reported frequency of interaction among the cluster's members. This process continues until all clusters are merged into a single group.

A cut-off communication frequency score of three was used to determine the number of clusters. Once the lowest intra-cluster frequency value dropped below three, the

hierarchical cluster analysis was stopped and the derived clusters used as the structural subgroups.

The results of the cluster analysis are presented by team in Tables 13-16. Individuals were randomly assigned numbers within teams to protect confidentiality. The superintendent (S) and team leader (TL) are identified. Individuals who did not meet the minimum interaction levels for group inclusion were left unclassified.

The structural subgroups of Team A are presented in Table 13. There were four subgroups among the 14 team members in April 1983. The largest subgroup had five members, the smallest subgroups had two members. Four subgroups existed in August 1983. The largest subgroup contained seven members and included the superintendent and team leader. The smallest subgroup consisted of two individuals. One team member was not classified. All of the 18 team members were classified into subgroups in August 1983. The 21 team members were sorted into five subgroups in March 1984. As in August, all team members were part of a group.

The 14 members of Team B were classified into four subgroups in April 1983. (See Table 14.) The largest subgroup contained five team members including the team leader. Three members and the superintendent formed a second subgroup. The final groups contained two or three people. In August 1983, four subgroups existed. Two of the 19 team members were not classified. In March 1984, five subgroups were derived. Although the superintendent and

Table 13

Production Network Subgroup Membership: Team A

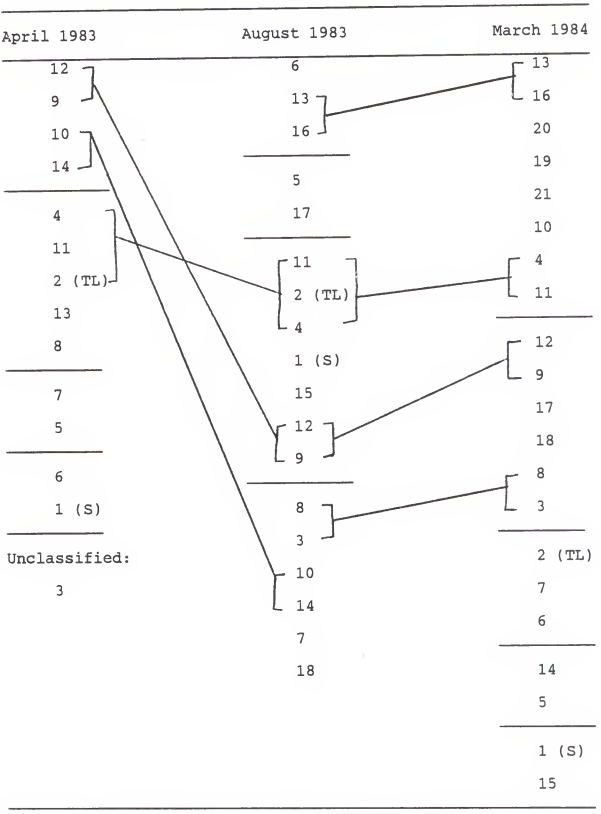
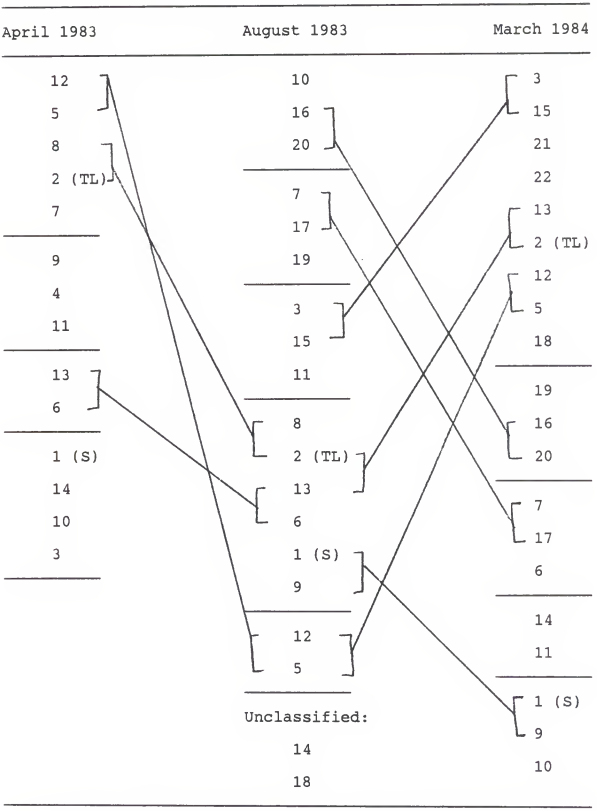


Table 14

Production Network Clique Membership: Team B



team leader were in the same subgroup in August, they were separated in March.

The results of the UCLUS procedure for Team C are presented in Table 15. In April 1983, three structural subgroups were identified. The superintendent was not classified. Two large groupings emerged. The largest contained six individuals, the second contained five. In August 1983, six subgroups emerged. Three of the groups were dyads. The largest group contained five team members. Three structural subgroups emerged in March 1984. Two individuals were not classified.

The analysis of Team D, shown in Table 16, identified five structural subgroups in April 1983. Two of the 14 team members were not classified. Each subgroup contained either two or three individuals. In August 1983, five subgroups again emerged. The largest subgroup contained four individuals. Five team members and the team leader were unclassified. In March 1984, five structural subgroups were derived. Of the 21 team members, 15 were categorized into subgroups. The largest contained five individuals.

Assessment of homogeneity. Hypotheses 1, 2, and 3 are stated in terms of the homogeneity of the structural subgroups with respect to personal characteristics, age and work as a central life interest, and technological factors, task assignment and module assignment.

Table 15

Production Network Subgroup Structure: Team C

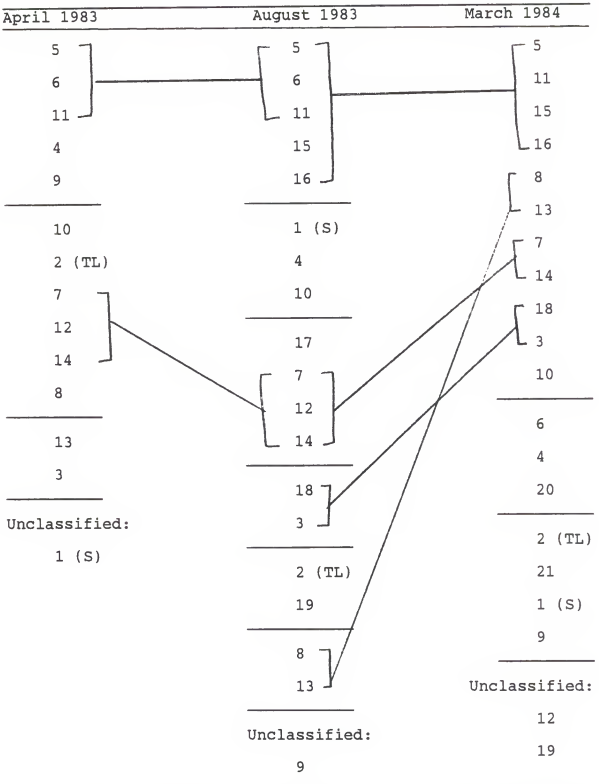
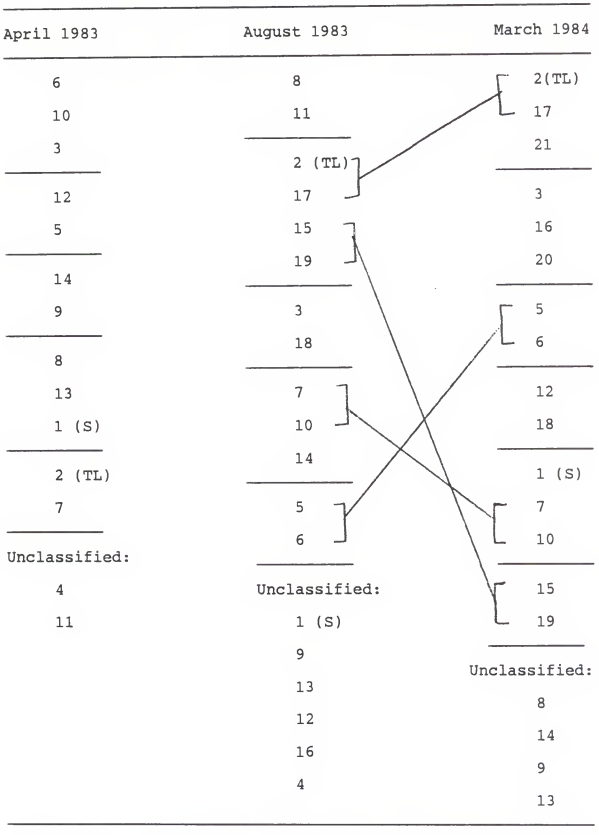


Table 16

Production Network Subgroup Structure: Team D



Age was reported by the respondents on the first questionnaire. Work as a central life interest was measured using a 32-item scale developed by Dubin (1956). Each item has a set of three possible responses. If a work-oriented answer is given, the item is scored as 1, otherwise 0. The items are then summed. A high score indicates a strong orientation toward work. The scale includes such questions as:

Interruptions bother me most

___ when working at my job

___ when working at home

___ hardly ever

and,

I am most interested in

___ things about my job

___ things I usually do around the house or in the community.

___ just about everything I do.

The internal reliability of the scale, Cronbach's α, was .710. Evidence of the construct validity of the scale has been presented by Dubin and Goldman (1972) and Dubin and Champoux (1974).

Homogeneity for the personal variables is based on a test of subgroup variance. If the variance of the subgroup is significantly less than the variance of the team, subgroup homogeneity is established. The test of variance homogeneity is distributed as an F-statistic computed as:

$$F = \frac{\text{variance}_{\text{team}}}{\text{variance}_{\text{subgroup}}}$$

Because the hypotheses tests only seek to identify subgroups with lower variance than the team, a one-tailed F-test was used (Montgomery, 1976).

The technological factors, task assignment and module assignment, were determined from the field observations. Each team was visited approximately three times a month. The researcher systematically observed the work teams in the early, middle, and late hours of each of the three days of a shift. Although the observation schedule was systematic, teams were not aware of the timing of visits. When the observer visited the plant, the task assignment and location of each individual were noted. (See Appendix A.)

The task assignment matrices were added on the basis of job and on the basis of module for the time period between communication network administrations. The job most frequently assigned and the job next most frequently assigned to the individual were used as his or her task assignments. A similar assessment was made for module assignments. Jobs such as quality assurance, floater, machine shop, and utility, fell into a "non-equipment based" category. There was only one production module in April 1983. Individuals were assigned either to this module or the "non-equipment based" location because of this restriction of range.

For the technological variables, homogeneity was judged to be present if there was a common task or module

assignment among the subgroup members. Subgroups were examined to determine if there were module /assignment commonalities among the members. Common task assignments were judged two ways. First, if individuals had the same job, they were said to have a common task assignment. The liner and rotofeed assignments were considered a single task because they quickly evolved into a single position. Second, in the larger subgroups (n>5), technical skill requirements were also considered. The superintendents and team leaders identified tasks which used similar technical skills (for example, conversion press and shellpress). If subgroup members shared these two tasks, they were defined as having a similar task assignment. The second category is broader than the first. It is useful in larger groups because there are many different task assignments. Basing an assessment of commonality on a single task would underestimate the technical homogeneity of the larger subgroups.

Table 17 provides an example of the assessment of task and module assignment homogeneity. The first subgroup has a "common task assignment" of quality assurance. Quality assurance is participant C1's second most frequently assigned task and C2's most frequent assignment. There is no "common module assignment" in subgroup 1. Subgroup 2 has a "common module assignment", module 3, but no common task assignment.

The means and standard deviations of the personal factors are presented, by team, in Tables 18-21.

Table 17

Task Assignment and Module Assignment
Homogeneity Example

	Task Assignment		Module Assignment	
	Most Frequent	Next Most Frequent	Most Frequent	Next Most Frequent
Subgroup 1				
C1	Shell-press	Quality Assurance	2	3
C2	Quality Assurance	Conversion Press	1	"Non-Equipment"
Subgroup 2				
C4	Shell-press	Utility	1	3
C5	Floater	Utility	2	3
C6	Shell-Press	Quality Assurance	3	"Non-Equipment"

Significant standard deviations are indicated. The common task and module assignments for the subgroups are also presented in these tables. If there was no common assignment, no entry was placed in the task assignment or module assignment columns.

Team A. The results of the homogeneity analysis for Team A are presented in Table 18. In April 1983, three of the four structural subgroups had "common task assignments". Two had "common module assignments" as well. The four individuals in subgroup 1 had a "common task assignment" in the liner/rotofeed. They also were assigned to module 1. The liner/rotofeed was a "common task assignment" and module 1 was a common module for the five team members in subgroup 2. The third subgroup (n=2) consisted of conversion press workers. They had no "common module assignment".

In August 1983, homogeneity within subgroups on the technological variables was exhibited. Two of the four subgroups had a "common task assignment". One of those had a "common module assignment". Also, another subgroup had a common module 1 assignment.

Three of the five structural subgroups in March 1984 had a "common task assignment". None had a "common module assignment". The eight members of the first subgroup had a common task assignment based on technical skill requirements; shellpress and conversion press. Subgroup 2 had common assignments at the conversion press and in the

Table 18

Team A Subgroup Characteristics
Means, Standard Deviations, and Commonalities

	Age	Work as Central Life Interest	Task Assign-ment	Module Assign-ment
April 1983	31.3 (7.97)	.457 (.144)		
Subgroup 1 (n=4)	30.8 (9.03)	.411 (.096)	Liner/ Rotofeed	1
Subgroup 2 (n=5)	30.6 (4.82)	.494 (.197)	Liner/ Rotofeed	1
Subgroup 3 (n=2)	27.5 (2.12)	.438 (.045)	Conversion Press	
Subgroup 4 (n=2)	43.0 (8.48)	.562 (.132)		
August 1983	32.9 (8.28)	.440 (.133)		
Subgroup 1 (n=3)	43.3 (8.14)	.531 (.225)		1
Subgroup 2 (n=2)	29.0 (4.24)	.407 (.088)	Liner/ Rotofeed	2
Subgroup 3 (n=7)	35.1 (6.84)	.452 (.123)		
Subgroup 4 (n=6)	27.5 (4.08)	.368 (.077)	Conversion Press	

Table 18

Continued

	Age	Work as Central Life Interest	Task Assign-ment	Module Assign-ment
March 1984	33.3 (7.74)	.449 (.156)		
Subgroup 1 (n=8)	33.2 (7.31)	.495 (.217)	SP/CP	
Subgroup 2 (n=6)	31.5 (7.18)	.358 (.075)	QA/CP	
Subgroup 3 (n=3)	38.3 (10.1)	.437 (.032)		
Subgroup 4 (n=2)	24.5 (2.12)	.525 (.078)	Conversion Press	
Subgroup 5 (n=2)	40.0 (4.24)	.506 (.213)		

quality assurance lab. The two individuals in subgroup 4 shared a conversion press task assignment.

Team B. The results of the homogeneity analysis for Team B are presented in Table 19. In April 1983, neither of the personal characteristics were common in subgroups. Three of the four subgroups had a "common task assignment", one of the four had a "common module assignment".

In August 1983, subgroup 3 had a statistically lower standard deviation than the team ($p<.05$) on the age variable. The mean of subgroup 3 was 28.3 years (s.d.= 1.53) while the team mean was 32.8 years (s.d.= 9.48). These three individuals also shared a "common task assignment" on the liner. None of the other four subgroups had common task or module assignments.

The results for March 1984 indicate that one subgroup was homogeneous with respect to age. Subgroup 4 had a lower average age than the team and a statistically lower standard deviation. The individuals in subgroup 2 had a common floating assignment. They also shared the "non-equipment based" location. Subgroup 3 members did not share a "common task assignment" but they did share the "non-equipment based" location.

Team C. The results of the homogeneity testing for Team C are shown in Table 20. Neither age nor work as a central life interest was a common subgroup characteristic.

In April 1983, two of Team C's three derived structural subgroups had a common liner/rotofeed task assignment. The

Table 19

Team B Subgroup Characteristics
Means, Standard Deviations, and Commonalities

	Age	Work as Central Life Interest	Task Assign-ment	Module Assign-ment
April 1983	34.0 (9.79)	.462 (.095)		
Subgroup 1 (n=5)	30.8 (4.40)	.465 (.086)	Liner/ Rotofeed	1
Subgroup 2 (n=3)	23.3 (4.00	.417 (.178)		
Subgroup 3 (n=2)	39.5 (28.9)	.438 (.088)	Liner/ Rotofeed	
Subgroup 4 (n=4)	34.0 (6.98)	.504 (.027)	Liner/ Rotofeed	
August 1983	32.8 (9.48)	.439 (.106)		
Subgroup 1 (n=3)	33.7 (4.90)	.513 (.031)		
Subgroup 2 (n=3)	35.7 (12.4)	.500 (.054)		
Subgroup 3 (n=3)	28.3* (1.53)	.312 (.162)	Liner	
Subgroup 4 (n=6)	36.5 (13.9)	.464 (.073)		
Subgroup 5 (n=2)	32.5 (7.80)	.435 (.092)		

Table 19

Continued

	Age	Work as Central Life Interest	Task Assign-ment	Module Assign-ment
March 1984	32.8 (9.20)	.436 (.104)		
Subgroup 1 (n=9)	27.8* (5.20)	.372 (.088)		
Subgroup 2 (n=3)	38.3 (11.1)	.531 (.031)	Floater	"Non Equip-ment"
Subgroup 3 (n=3)	39.0 (18.2)	.490 (.047)		"Non Equip-ment"
Subgroup 4 (n=2)	29.5* (0.71)	.343 (.175)		
Subgroup 5 (n=3)	38.3 (4.00)	.505 (.032)		

*p<.05

Table 20

Team C Subgroup Characteristics
Means, Standard Deviations, and Commonalities

	Age	Work as Central Life Interest	Task Assign-ment	Module Assign-ment
April 1983	30.7 (7.68)	.396 (.100)		
Subgroup 1 (n=5)	30.2 (9.12)	.425 (.138)	Liner/ Rotofeed	1
Subgroup 2 (n=6)	30.2 (5.67)	.391 (.056)	Liner/ Rotofeed	
Subgroup 3 (n=2)	31.0 (15.6)	.313 (.132)		1
August 1983	30.8 (7.13)	.400 (.096)		
Subgroup 1 (n=5)	27.2 (6.43)	.418 (.078)	Liner	
Subgroup 2 (n=3)	32.5 (4.43)	.461 (.066)	Liner/ Rotofeed	
Subgroup 3 (n=4)	32.5 (4.43)	.353 (.099)		2
Subgroup 4 (n=2)	27.5 (2.82)	.422 (.023)		
Subgroup 5 (n=2)	33.0 (2.82)	.469 (.088)		
Subgroup 6 (n=2)	32.0 (14.1)	.297 (.110)		

Table 20

Continued

	Age	Work as Central Life Interest	Task Assign-ment	Module Assign-ment
March 1984	31.7 (7.36)	.398 (.106)		
Subgroup 1 (n=11)	29.9 (6.97)	.388 (.067)	SP/CP	
Subgroup 2 (n=3)	29.0 (8.60)	.458 (.125)	QA	
Subgroup 3 (n=4)	40.0 (6.38)	.412 (.166)		"Non Equip-ment"

*p<.05

five members of subgroup 1 and the six members of subgroup 2 shared this task assignment. Additionally, the members of subgroup 1 had a "common module assignment" in module 1. Subgroup 3 members also shared this module 1 assignment.

There was little task or module homogeneity among the subgroups in August 1983. Of the six subgroups at this time, only two had a "common task assignment" and one a "common module assignment".

In March 1984, the first subgroup, consisting of 11 individuals, had a "common task assignment" of shell press and conversion press. Although they worked at tasks requiring similar skills, the members of subgroup 1 did not share a "common module assignment". The three individuals in the second subgroup shared a common quality assurance task assignment. As with the first subgroup, there was no "common module assignment". The third subgroup shared a "non-equipment based" location.

Team D. The results for Team D are presented in Table 21. In April 1983, two of the five structural subgroups had "common task assignments". The two individuals in subgroup 2 shared the liner/rotofeed assignment. Subgroup 4 (n=3) members shared a common shellpress assignment. There were no "common module assignments", nor was there homogeneity with respect to the personal characteristic variables.

By August 1983, three of the five subgroups had "common task assignments". Subgroup 2 had a common task assignment of liner/rotofeed. The two members of subgroup 3 had the

Table 21

Team D Subgroup Characteristics
Means, Standard Deviations, and Commonalities

	Age	Work as Central Life Interest	Task Assign-ment	Module Assign-ment
April 1983	33.0 (6.01)	.441 (.159)		
Subgroup 1 (n=3)	27.0 (6.56)	.361 (.164)	Liner/ Rotofeed	
Subgroup 2 (n=2)	32.0 (2.83)	.415 (.144)		
Subgroup 3 (n=2)	33.5 (2.12)	.688 (.132)		
Subgroup 4 (n=2)	40.0 (4.00)	.471 (.083)	Liner/ Rotofeed	
Subgroup 5 (n=2)	36.5 (3.54)	.454 (.155)		
August 1983	32.9 (6.28)	.424 (.158)		
Subgroup 1 (n=2)	33.0 (4.24)	.383 (.188)		
Subgroup 2 (n=4)	34.0 (5.01)	.360 (.210)	Liner/ Rotofeed	
Subgroup 3 (n=2)	28.5 (7.78)	.532* (.001)	Bagging	
Subgroup 4 (n=3)	32.3 (6.51)	.382 (.196)	SP	
Subgroup 5 (n=2)	27.5 (9.19)	.329 (.022)		

Table 21

Continued

	Age	Work as Central Life Interest	Task Assign-ment	Module Assign-ment
March 1984	34.0 (7.64)	.423 (.154)		
Subgroup 1 (n=3)	38.7 (12.7)	.448 (.100)		
Subgroup 2 (n=3)	37.0 (4.24)	.470 (.090)	QA	"Non Equip-ment"
Subgroup 3 (n=2)	27.5 (9.19)	.329 (.022)		
Subgroup 4 (n=2)	26.5 (4.95)	.524 (.011)		
Subgroup 5 (n=5)	36.0 (6.68)	.304 (.168)	Floater	

*p<.05

bagging task in common. The three individuals in subgroup 4 were frequently assigned to the shell press. There was no "common module assignment" among the five subgroups. One subgroup was homogeneous with regards to the member's work as a central life interest score. The standard deviation for subgroup 3 (.001) was significantly below the team's standard deviation (.158).

The five structural subgroups derived from the production communication network of March 1984 showed commonality with respect to task and module assignments. Subgroup 2 had a common quality assurance task assignment, as well as a common "non-equipment based" location. The five individuals in subgroup 5 had the floater task in common. In none of the subgroups did age or work as a central life interest attain statistical significance.

Table 22 presents a summary of the homogeneity findings. The percentage of subgroups exhibiting homogeneity on either age or work as a central life interest is listed in the individual difference column. The percentage of derived subgroups exhibiting homogeneous task or module assignments is listed in the technological factors column.

Hypothesis 1. Hypothesis 1 states that at time 1, subgroups should be homogeneous with respect to personal characteristics and less homogeneous with respect to technical factors because of the lack of a significant technological constraint. If this hypothesis is supported, the

Table 22

Percentage of Subgroups Exhibiting Homogeneity

	Individual Differences	Technical Factors
April 1983 (t_1)		
Team A	0%	75%
Team B	0%	75%
Team C	0%	100%
Team D	0%	40%
Mean	0%	72.5%
August 1983 (t_2)		
Team A	0%	75%
Team B	20%	20%
Team C	0%	50%
Team D	20%	60%
Mean	10%	51.25%
March 1984 (t_3)		
Team A	0%	60%
Team B	20%	40%
Team C	0%	100%
Team D	0%	40%
Mean	5%	60%

percent of subgroups exhibiting individual difference homogeneity should be greater than the percentage of subgroups exhibiting technological factor homogeneity in April 1983. This was not the case. None of the subgroups were statistically homogeneous with respect to the individual difference variables. Commonality on the basis of task and module assignments dominated subgroup formation (72.5%).

Hypothesis 2. Hypothesis 2 suggests that as technological constraints begin to exert influence, structural subgroups will be moderately homogeneous with regard to both personal characteristics and technological factors. This hypothesis was supported. An average of 10% of the subgroups were homogeneous with regards to age and work as a central life interest. A moderate amount (51.25%) were homogeneous with respect to task and module assignment.

Hypothesis 3. The third hypothesis, decreased homogeneity among the personal characteristic variables and increased homogeneity among the technological variables at the third time point, was also supported. The percentage of subgroups exhibiting technological factor commonality increased to 60%. Homogeneity based on individual difference variables declined to 5% in March 1984.

The Relationship between Stages of Group Development and Autonomous Work Groups

The next two hypothesis concern the intra-group conflict stage (2) of group development.

Hypothesis 4. If semi-autonomous work groups follow the developmental sequence described in Chapter I, the number of structural subgroups should exhibit a concave pattern over time; a low number of groups during the orientation stage (1), a higher number during the conflict stage (2), and a low number during the cohesiveness stage (3). The number of structural subgroups is simply the number of clusters derived by the UCLUS procedure (Tables 13-16). Figure 9 shows the number of subgroups over time by team. The concave pattern was shown only by Team C. Beginning with three subgroups in April, six subgroups emerged in August. By March 1984, there were only three subgroups. Teams A, B, and D had either four or five subgroups across all time points. While one team supported hypothesis 4, the other three did not.

Hypothesis 5. The lowest team cohesiveness score can also be used as an indicator of the conflict stage (2) of group development. During the conflict stage (2), the high cohesiveness which characterized the orientation stage (1) has dissipated. Subgroups form and there is hostility and infighting. Team cohesiveness suffers. During the

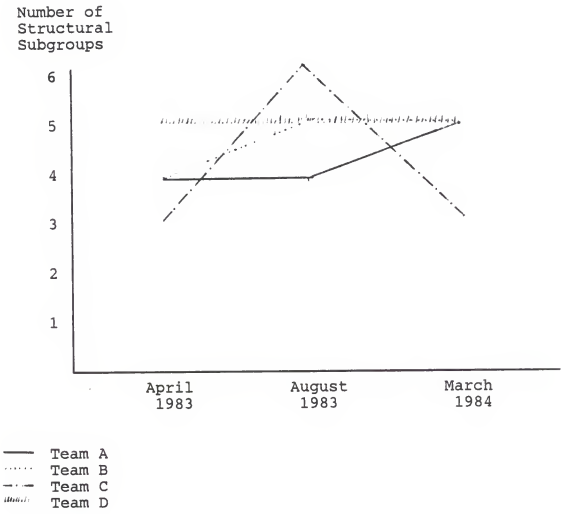


Figure 9

Number of Structural Subgroups over Time:
By Team

cohesiveness stage (3), group cohesiveness scores should rise as conflicts are settled and group norms begin to develop.

Group cohesiveness was measured using a five-item scale developed by Stogdill (1965). This scale assesses the cooperativeness and teamwork of the group. Respondents were asked to indicate, on a 5-point Likert scale, their agreement with such items as:

The members of this Team regard each other as friends.

The Team members know they can depend on each other.

The Team members stand up for each other.

Evidence of the reliability and validity of the scale is presented in Greene (1976, August). Table 23 presents the means, standard deviations, coefficient α reliabilities (Cronbach, 1951), and test-retest correlations for the scale. The coefficient α's are acceptable (Nunnally, 1978).

The group cohesiveness scores are presented in Figure 10. All teams exhibited a general decline in cohesiveness between April and August 1983. Teams A, C, and D showed an increase from August to December 1983 while Team B continued its downward trend. Between December 1983 and April 1984, the group cohesiveness score for Teams B and D rose. The scores for Teams A and C fell dramatically.

The concave pattern of the team cohesiveness scores supports hypothesis 5. This pattern varied for each team and suggests that the teams had different time frames for passage through these stages. Using the lowest cohesiveness

Table 23

Means, Standard Deviations, Coefficient α's, and Test-Retest Correlations
Group Cohesiveness

	Mean	Standard Deviation	Reliabilities[a] and Correlations April 1983	August 1983	December 1983	April 1984
April 1983 (n=37)	4.40	.491	.94	.38*	.17	.14
August 1983 (n=59)	4.02	.832		.95	.46*	.16
December 1983 (n=56)	4.08	.804			.96	.10
April 1984 (n=38)	3.88	.759				.95

*p<.05
[a]Coefficient α reliabilities are entered on the main diagonal.

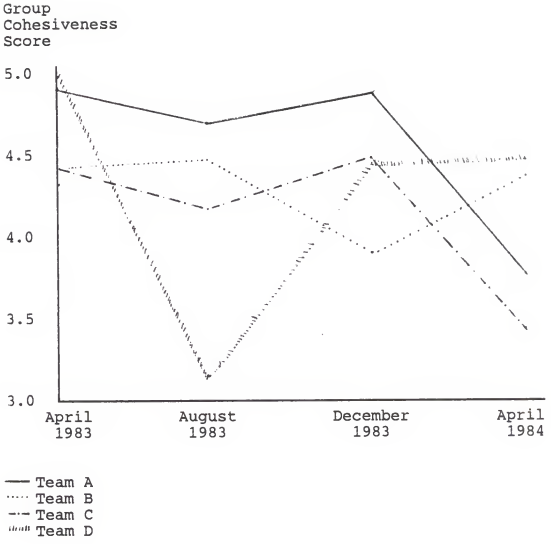


Figure 10

Group Cohesiveness Scores over Time:
By Team

score as determinative of the conflict stage (2), Team D was in "conflict" in August 1983, and Team B was in "conflict" in December 1983. After a long orientation stage (1), Teams A and C finally entered the conflict stage (2) in early 1984. A summary of the results is presented in Figure 11.

The Relationship between Structure and Outcomes

The relationship between social structure and outcomes was addressed in three ways. First, the correlations between group structure and performance were tested. Then the relationship between individual structure and performance was examined. Finally the relationship between individual structure and satisfaction was explored.

Hypothesis 6. The measure of group performance used to test both H_6 and H_7 was based on conversion press production for the team's 12 hour shift. Actual production levels were corrected for substandard quality. The actual production figure used in the analyses is a team average for the previous four or seven months. For example, the April 1983 figure is the team's average production from the plant start-up through April 15, 1983. The August 1983 figure is the average production from April 16, 1983 through August 15, 1983. The March 1984 figure is the average production from August 16, 1983 to March 15, 1984. The mean levels of group production are presented in Table 24.

	Team A	Team B	Team C	Team D
Stages				
Orientation (1)	early-1983 through late-1983	early-1983 through mid-1983	early-1983	early-1983
Conflict (2)	early-1984	late-1983	mid-1983 through early-1984	mid-1983
Cohesiveness (3)		early-1984		late-1983

Figure 11

Group Development Stages

Table 24

Mean Production per 12-Hour Shift:
By Team

	April 1983	August 1983	March 1984
Team A	709.6	1148.7	2605.5
Team B	731.4	1365.5	2482.8
Team C	561.6	1305.6	2755.0
Team D	582.2	1355.4	2646.3

The independent variable for the test of H_6 is the overlap between the production issues communication (PIC) network and the social and friendship matters communication (SFMC) network. These values are reported in Table 11.

There was a negative correlation between group production and PIC/SFMC network overlap. (See Table 25.) The correlation was -.94 in April 1983 ($p<.10$), -.92 in August 1983 ($p<.10$) and -.75 ($p<.25$) in March 1984. These correlations fall short of the conventional level of statistical significance ($p<.05$). However the strong negative result does not support hypothesis 6: The overlap between the production issues communication matrix and the social and friendship matters communication matrix will be positively related to group performance.

Hypothesis 7. A second measure of group structure, dyadic stability, was correlated with group production. Dyadic membership is defined as an individual's persistent relationship with another individual.

The dyadic stability index is based on dyadic membership within the structural subgroups. Subgroups were examined to identify pairs of individuals who remained within the same subgroup over time. These dyads are identified and connected in Tables 13-16. The dyadic stability index is the proportion of stable dyads at a given time period to the number of possible dyads at that point. The formula is

$$\text{Dyadic Stability Index} = \frac{\text{the number of stable dyads}}{[n(n-1)]/2}$$

Table 25

Correlation between Group Production
and Production/Social Communication Overlap

	Production/Social Overlap		
	April 1983	August 1983	March 1984
Production			
April 1983	-.94* (n=4)		
August 1983		-.92* (n=4)	
March 1984			-.75 (n=4)

*p<.10

where n is the number of team members. Several stable triads were identified. For the purposes of the dyadic stability index, one triad was considered the equivalent of three dyads.

The dyadic stability indices for each team are shown in Table 26. They range from .000 (Team D- April 1983) to .076 (Team C- August 1983). All teams had less than 10% of the possible dyads exhibiting stability.

The Pearson product moment correlations between the dyadic stability index and team production are presented in Table 27. None of the correlations reached statistical significance. Hypothesis 7 was not supported.

Hypothesis 8. The relationship between performance rankings and individual dyadic membership was tested. Dyadic membership was based on the structural subgroups elicited by the cluster analysis. This variable was coded 1 if the individual was a member of a stable dyad (circled in Tables 13-16), 0 if not.

Individual performance was measured during July and August when the team superintendents and the team leaders participated in interviews. The superintendents and team leaders ranked their team members in response to the question: "Rate these people in order of their contribution to the total team effort: Who would you most hate to lose?" To facilitate ranking, 3" by 5" cards with the names of the team members were prepared. They were given the cards in

Table 26

Dyadic Stability Index

	April 1983	August 1983	March 1984
Team A	.055	.052	.024
Team B	.033	.047	.029
Team C	.066	.076	.032
Team D	.000	.023	.019

Table 27

Correlation Between Group Production and Dyadic Stability

	Dyadic Stability		
	April 1983	August 1983	March 1984
Production			
April 1983	.09 (n=4)		
August 1983		.01 (n=4)	
March 1984			.13 (n=4)

random order and asked to reorder the individuals with the greatest contributor on top. Eighteen was the highest rank, one was the lowest.

Members of Teams A, C, and D were ranked by their superintendent and team leader. Team B's superintendent was not available during this period: only the team leader's rankings were obtained. The interrater reliability estimates, Spearman's rank order correlation coefficients (1904), are presented in Table 28.

There was a positive correlation between August 1983 performance rank and the August 1983 dyadic membership ($r=.31$, $p<.05$). Highly ranked team members were more likely to be members of a stable dyad than lower ranked members. Hypothesis 8 was supported.

To further clarify the relationship between dyadic membership and individual performance, a part correlation coefficient was computed between performance and dyadic membership holding skill level constant. Skill level was used to control the performance measure for employee skill differences. The part correlation coefficient was .28 ($p<.05$). Thus, dyadic stability explains 7.8% of the variance in individual performance after the effects of skill level are considered.

Hypothesis 9. According to advocates, another result of an STS implementation is increased employee satisfaction (e.g. Trist, 1981). Hypothesis 9 was developed to examine

Table 28

Interrater Reliability Estimates
Individual Performance

	Estimate
Team A	.914
Team B	---
Team C	.826
Team D	.738

this contention. The independent variable, dyadic membership, is discussed above.

Job satisfaction was assessed using a modified and shortened (20-item) version of the Minnesota Satisfaction Questionnaire (Weiss, Dawis, England, and Lofquist, 1967). The items describe various aspects of the job and respondents indicate the extent of their current satisfaction with these aspects. A 5-point continuum ranging from "very dissatisfied" to "very satisfied" was used for scoring. Item responses were averaged to obtain a job satisfaction score. Examples of the items include:

The working conditions.

The chances for advancement on this job.

The praise I get for doing a good job.

The chance to work alone on the job.

Satisfaction was measured at four time points. Because the communication networks were only administered at three time points, only three of the available job satisfaction scores were used (April 1983, August 1983 and April 1984). Means, standard deviations, coefficient α reliabilities, and test-retest correlations are presented in Table 29.

The correlations between dyadic membership and individual job satisfaction are presented in Table 30. None of the correlations were significant. Hypothesis 9 was not supported.

Table 29

Means, Standard Deviations, Coefficient α's and Test-Retest Correlations
Job Satisfaction

	Mean	Standard Deviation	Reliabilities[a] and Correlations April 1983	August 1983	April 1984
April 1983 (n=37)	4.34	.424	.94	.72*	.31
August 1983 (n=58)	4.02	.530		.95	.31
April 1984 (n=38)	3.82	.751			.96

*p<.05
[a]Coefficient α reliabilities are entered on the main diagonal.

Table 30

Correlation between Job Satisfaction and Dyadic Membership

	Dyadic Membership		
	April 1983	August 1983	March 1984
Satisfaction			
April 1983	.01 (n=39)		
August 1983		-.04 (n=59)	
April 1984			-.19 (n=38)

Summary

Chapter III presented the results of the analyses used to examine the study's propositions. There was some evidence that the homogeneity of structural subgroups with respect to personal characteristics and technological factors changed across time. Initially, subgroups formed on the basis of technological variables. By August 1983, personal characteristics gained slightly in importance, while the effects of technological variables seemed to decline. The percentage of subgroups exhibiting technological factor homogeneity increased by March 1983. The percentage with significant age and work as a central life interest scores decreased.

Support was mixed for the group development hypotheses (H_4 and H_5). The concave subgroup graph of Team C clearly supported the conflict stage (2) of group development. The other teams did not. The results using group cohesiveness convexity as an indicator of group development stages were more consistent. Using this measure, it appears that all work groups entered the conflict stage (2). However they did so at different times. The relationship between structural characteristics and performance (Proposition 6) was supported when group structure was defined as the congruence of the social and technical systems. There was no support for a relationship between group performance and dyadic stability. A significant relationship existed between individual performance and dyadic membership. Hypothesis 9

regarding the relationship between dyadic membership and job satisfaction was not supported.

CHAPTER IV

DISCUSSION AND CONCLUSIONS

The nature of semi-autonomous work group structure was studied in a plant which based its design on sociotechnical systems (STS) concepts. The study drew its theoretical foundations from STS and the group development literature. The results of the data analyses will be interpreted and discussed in this chapter. This discussion will by supplemented by the observational field notes. The implication of the results for STS and the limitations of the study will also be explored.

The Sociotechnical System

Advocates of STS contend that both technological characteristics and personal characteristics will influence the STS (e.g. Trist, 1981). At Smithton, the start-up was planned to gradually increase the amount of technology (equipment) in the plant. In the beginning, only one production line was running. Personal characteristics should have had their greatest impact during this early phase of operation because production and technical constraints were low. (See Figure 1.) As additional modules were added, technology and production demands increased.

The technical system exerted more control over the workers. So, technical factors should be influential in determining the STS in later phases of operation and the influence of individual differences should decline. Propositions 1, 2, and 3 reflect this argument. (See Table 5.)

Analysis of the structural subgroups shows that personal factors were not important to the formation of subgroups during the first measurement period (April 1983). However, 72% of the subgroups had common technological characteristics. In August 1983, the percentage of subgroups that exhibited homogeneity based upon personal characteristics increased (10%). The role of technological factors declined (51.25%). By March 1984, the effects of the technological factors were stronger. A higher percentage of the subgroups had common technological characteristics (60%). A lower percentage had common personal characteristics (5%).

Overall, the personal characteristics assessed had little relationship to the formation of subgroups. This is surprising given the theory and research regarding group formation which shows that individuals form groups based on similar characteristics (e.g. Lott and Lott, 1965). There are several possible explanations why personal characteristics were not strong in this study.

First, group members may have had insufficient knowledge of others due to the time constraints imposed by the technical system. Figure 1 shows that even in the early stages of operation, there was limited behavioral latitude

in the STS. The new equipment, with its attendant problems and the high production goals set by management, may have forced the development of technically-based subgroups.

Interpersonal attraction based on personal characteristics is premised on the assumption that individuals know each other. The technological context may have left little time for individuals to become acquainted. A team member could easily identify another's work assignment, but not have adequate opportunity to find a common basis for future relationships.

Still, the socialization process, which allowed the first two groups of 20 workers to train together, should have provided an adequate, though informal, opportunity for getting acquainted. Individuals spent time together in the community college classes. Despite this interaction, the initial subgroups did not develop around personal characteristics. Nor did they develop around the training groups. Perhaps the technical aspects of the training took priority.

In later periods, there was scattered evidence that personal characteristics became more important to subgroup membership. For example, in periods 2 and 3, 10% and 5% of the subgroups had common personal characteristics. The numbers are low so it is difficult to be conclusive about their meaning.

Methodological considerations may be another reason for the lack of effects of personal characteristics in group formation. The F-test used to determine homogeneity among

the interpersonal factors is a rigorous test. It is difficult to attain statistical significance with the small subgroup sizes (Montgomery, 1976). On the other hand, the assessment of commonality among the technological factors is based on frequencies. It is a more "subjective" test and its statistical significance is not ascertainable.

Another methodological issue is the limited number of personal characteristics examined. Age was used because previous research indicates that it is a factor in interpersonal attraction (Lott and Lott, 1965). Also, age is a useful surrogate for education, experience, marital status, and life-stage (e.g. Levinson, 1977). Work as a central life interest was selected because of management's efforts to make it salient. However, other individual characteristics may be more important to subgroup formation. For example, subgroups may be a function of racial or ethnic background or religion (Monge and Eisenberg, in press). Further research is needed with regard to the specific personal characteristics which affect subgroup formation.

The strongest result is the technological effect on subgroup formation. Previous research indicates that propinquity, the physical distance between individuals, is a significant predictor of group development (e.g. Festinger et al., 1950; Allen, 1977; Monge and Kriste, 1980). Although propinquity was not assessed directly, the production module assignment of workers is an indicator of physical proximity. Individuals assigned to the same module work

near each other. There were some subgroups which exhibited homogeneity based on module assignments. However, module assignment seemed to be less important than task assignment. Subgroups with a "common task assignment" outnumbered those with a "common module assignment" more than three to one. Thus, the kind of work that one does seems more important than proximity.

The impact of task assignment on the formation of structural subgroups is consistent with the arguments advanced by Fry (1982) about the technological imperative. The technological imperative argues that there is a strong relationship between an organization's technology and its structure (e.g. Fry, 1982). While this research (cited in Fry, 1982) focuses upon measures of formal structure, it seems reasonable to expect that there would be similar effects on the informal structure.

The effects of technology on group structure at Smithton seem reasonable when technology is considered in terms of the task routineness/non-routineness dimension. Non-routine tasks are those for which there are few established techniques for task accomplishment. Furthermore, there may be uncertainty about the success of these techniques in a particular situation (Perrow, 1975). Using this definition, the equipment at Smithton was non-routine. It was prototypic. None of the production workers were familiar with it, even those with similar work experiences. Non-routineness of the technology stemmed from an

insufficient knowledge of task accomplishment. If this is so, then individuals may have been motivated to seek task information from those working on the same equipment. This would explain the strong role of technology in the initial phase of operation. When tasks are more routine, personal factors may become more relevant to subgroup formation.

There is some evidence to support this interpretation. The liners and rotofeeds posed particularly difficult problems during Smithton's start-up. In April 1983, 90% of the structural subgroups exhibiting task homogeneity had the liner/rotofeed assignment. This dropped to 63% by August 1983. No subgroups had the common liner/rotofeed assignment in March 1984. By this time the liners and rotofeeds were running smoothly--the task had become routine.

When problems developed on other equipment, those tasks became the basis for technological homogeneity. There were serious quality problems in the middle of 1983. Customers threatened to stop purchasing the product because the plant was producing lids which leaked under pressure and lids which would not open. The quality assurance and conversion press task assignments became non-routine. The conversion press performed the scoring on the lid, the point where the leaking occurred. The implementation of correct quality assurance procedures was important in reducing the probability of shipping "bad" lids. After those quality problems began in late 1983, both quality assurance and conversion press task assignments became bases for subgroup formation.

Seventy-five percent (75%) of the subgroups in March 1984 exhibited homogeneity based on these assignments.

Implications. The role of technology must be recognized more explicitly in the STS approach. There could be, for instance, some additional thought to the development of guidelines for effective use of autonomous work groups. The specific characteristics of the technology may need to be considered. For example, in an organization with a routine technology, one would expect that individual differences would play a greater role in defining the STS. In this type of organization, workers are not confronted by unfamiliar technological problems. The salience of the technology is reduced. So, personal factors may become important to subgroup formation. Technological characteristics other than routineness, may need to be considered. At Smithton, the technology was long-linked and highly automated (Thompson, 1967). The independent effects of these characteristics is not clear because of the non-routine nature of the tasks.

The effects of intensive and mediating technologies on STS may be quite different. Mediating technologies are those that bring together clients and services. This type of technology may encourage subgroup formation based on similar clients. In a bank, for instance, loan officers dealing with corporate clients may form a subgroup, especially if the procedures for serving these customers are not

well established. If the procedures are established, other factors may influence subgroup formation.

The effects of the level of automation on STS development are not known. Under highly automated conditions, it would seem that workers would have more opportunities for informal interaction. Their job is one of monitoring the equipment. The added time for interaction might facilitate the discovery of common personal characteristics. Certainly, these aspects of the technology deserve further consideration.

Autonomous work groups are often implemented as a panacea for a variety of organizational problems, e.g. poor production, low morale. Despite the overt commitment to an autonomous work group structure which initially exists in most STS implementations, the technical system may work more effectively with something other than an autonomous work group. The reversion to previous work structure occurred in the Ahmedabad weaving sheds (Miller, 1978). Additional training was done to regain the success of the work groups. However, the long term effects of this retraining are not reported. If the technical system was not changed, reversion to previous structures may have again occurred. Retraining merely reawakens the commitment. It does not change the underlying technological causes for reversion.

Another factor to consider is the optimal group size. At Smithton, groups grew from 14 to 22 individuals. This may have been too big. Studies of group size indicate that

7-10 is the maximal number of members for group functioning (Steiner, 1972). Individual interaction, already affected by the technology, may have been further affected by the number of group members. The larger the group the more difficult it is to become familiar with others. The appropriate work group size may have to be considered when designing an STS implementation.

The relative instability of the production issues communication (PIC) network could have some implications for STS. Table 11 indicates that there was substantial change in these communication matrices over time. Some of this was expected as new workers were added to the work groups. In a small work group, adding new members is likely to change communication patterns (Monge and Eisenberg, in press). However, it is surprising that there was still instability after 15 months of operation (December 1982-March 1984). The plant seemed to have worked out its production problems and the level of job rotation had dropped. However, the results here are consistent with Monge and Eisenberg (in press). They suggest that communication networks are always in a state of flux. It is not clear what causes the changes or what features characterize stability (Monge and Eisenberg, in press). Two factors which could account for the instability are the addition of new members and the changing nature of the technological problems. It has been argued that the technical basis for group membership changed

from the liner/rotofeed to quality assurance and the conversion press as quality became a problem in late 1983.

STS seems to suggest that a balance between the social and technical systems is eventually achieved (e.g. Trist, 1981). Perhaps, the Smithton study was not long enough for equilibrium to have occurred. On the other hand, subgroup equilibrium may be a short-term phenomenon and instability a natural feature of all work groups. If so, this must be recognized more explicitly by those studying groups in organizations. Further, an important question remains. What is the effect of different degrees and types of instability on group performance and member reactions?

Instability is not necessarily bad. Changing communication patterns prevent stagnation. New and innovative ideas can be generated as work group members shift from one subgroup to another (Granovetter, 1973). These "weak links" have been empirically linked to the transfer of new information (Granovetter, 1973). He has shown that information transfers through those who are not in one's subgroup. External ties are important in disseminating new information. Thus, the ebb and flow in subgroup structure may be crucial to continued innovation. Where the technology is non-routine, an unstable structure in which individuals continually change their interaction patterns would seem necessary to solution of the novel problems.

Instability of the structure may be an advantage in the management of innovative, non-routine technologies.

Managers may be able to build instability into the work setting. For example, the technical system could be designed to rotate workers among different tasks. This may enhance the instability of the interaction patterns. Besides increasing job rotation, managers may want to schedule employee rest breaks, training classes, or overtime hours, so as to increase the contact among the work group members.

Group Development

Group development theory was used to describe the process through which the semi-autonomous work group becomes a functioning unit. The group development process consists of four stages. The orientation stage (1) is characterized by initiation to the task and the group. During this stage, the "ground rules" of group functioning are discovered. The second stage is a conflict stage (2). Hostility occurs and infighting is common. There is a decrease in group cohesiveness and subgroups proliferate during this stage (Heinen and Jacobson, 1976). In the cohesiveness stage (3), group solidarity develops and there is structural integration of the subgroups. Norms are established to insure the group's viability. Finally, the maturation stage (4) is reached. The group becomes a problem-solving instrument, effectively dealing with external demands.

Hypotheses 4 and 5 suggested that the conflict stage (2) of group development could be identified by an analysis

of the number of structural subgroups and group cohesiveness scores. Since one characteristic of the conflict stage (2) is the proliferation of subgroups, identification of this stage through an increase in the number of subgroups was suggested. During the orientation stage (1), few subgroups should exist. After the conflict stage (2), the number of subgroups should diminish as the integration of the cohesiveness stage (3) begins. Another characteristic of the conflict stage (2) is low group cohesiveness. It was hypothesized that there would be a high cohesiveness score during the orientation stage (1), a low cohesiveness score during the conflict stage (2), and a high cohesiveness score during the cohesiveness stage (3).

Identification of the group development stages using the number of subgroups (H_4) proved inconclusive. The number of subgroups did not exhibit a convex pattern. (See Figure 9). In only one group did this pattern occur. The lack of results from the analysis of the number of structural subgroups may be a function of the technological requirements. As discussed previously, the subgroups were related to the technical characteristics of the work environment. There was little latitude for the self-selection suggested by the group development literature which, incidentally, fails to consider technology in the development of groups. When considered in this light, the lack of results with respect to the number of structural subgroups is not surprising.

The analysis of the cohesiveness scores suggests that the groups went through the group development stages, but at different rates. These scores represent perceptions of closeness (or lack of conflict), unaffected by the influences of the technical system. Thus, group cohesiveness scores may be a better indicator of group development than the number of structural subgroups.

Further understanding of the group development process at Smithton was gained by examination of the field notes.

Team A. The group cohesiveness score for Team A declined sharply between December 1983 (4.35) and April 1984 (3.85). This decrease suggests that the conflict stage (2) of group development occurred in early 1984. (See Figure 11.)

During the orientation stage (1), the intra-work group relations of Team A were very congenial. Through early 1983, team members frequently reported the good feelings they had for the team. One worker remarked in January 1983, "We have a real good time, like a family. We are a happy go lucky group." A second worker reported, "These are good people and this is a good team." Another said, "This team works well together." When a team member had not had a break, other team members attempted to facilitate breaks for them, occasionally without the individuals' knowledge.

The orientation stage (1) of group development is also characterized by deference to the supervisor and informal leaders. An example of this deference was exhibited by team

members in May 1983. The superintendent and team leader were sitting in the break room telling "war stories" about raising children and the good old days. Other team members sat quietly at the table and listened. They rarely intervened with their own stories.

Hostility began to surface toward the informal leaders in June 1983. A worker, identified by the researcher as an informal leader, asked an operative to relieve another worker. The operative commented, "[She] wants me to interrupt my lunch break to relieve [another worker] so [the other worker] can have a break." The operative seemed angry but did comply. Team morale appeared to decline in mid-1983, although the group cohesiveness score remained high. Statements by team members that, "We got the best damn team here" were met with some disagreement (June 1983). Tension also arose from a wide-spread feeling among the less-tenured workers that longer-tenured employees avoided low-status job assignments.

By January 1984, there had been a drop in the group cohesiveness score suggesting that Team A was in the conflict stage (2). (See Figure 10.) The team leader and informal leaders were the focus of hostility. Practical jokes were played on an informal leader because he was "getting too high and mighty and he [couldn't] get along with people." There was overt conflict between the team leader and team members. One member said, "Everyone is

turning on [the team leader] now. No one likes him and most avoid him."

This negative feeling continued through March 1983. A revealing incident occurred in the break room. Several team members were sitting around the table joking. There was a lot of talk and laughter. The team leader walked in and sat down at the table. There was absolute silence. No one spoke for at least a minute. Then people began talking and joking about other things but with less enthusiasm than before he entered.

The study ended before evidence of the cohesiveness stage (3) emerged. A group cohesiveness score in August 1984 or December 1984 may have shown an increase. But the study did not last that long. The field notes did not indicate a decrease in the hostility or an increase in group cohesiveness or morale.

Team B. The analysis of the field notes for Team B indicates a relatively smooth developmental process. There appeared to be little fluctuation in member cooperativeness. Also, there were few incidents of problems with the team superintendent and team leader. Those that did occur were minor. For example, one worker indicated that the superintendent and team leader did not respond quickly and fully to questions. This was contradicted by several other team members who cited specific examples of quick response or direct coaching. Further, the team leader believed that the

team trusted him and the superintendent. There was no indication of the problems between the newer employees and longer-tenured employees which seemed to confront other teams.

The field notes suggest that Team B's conflict stage may not have occurred during the study period, or if it did occur, it was mild relative to other teams. Team B's cohesiveness score shows the smallest drop of the four work teams. Team B's score dropped only .29 points while other scores dropped .50 (Team A), .72 (Team C), and 1.17 points (Team D). This moderate drop supports the conclusions suggested by the field notes.

If this interpretation is correct, the lack of a strong conflict stage in Team B's development may be attributable to its superintendent. He was generally recognized as the most technically experienced superintendent and had worked on other plant start-ups. He was highly committed to developing the skills of all the team members. For example, individuals were slowly rotated through the job assignments to facilitate training. He spent much time coaching individual workers on their jobs. Additionally, the superintendent encouraged after-hours socializing. Parties, trips, and informal get-togethers were common. He provided the technical and social support for team members which may have contributed to the group development of Team B.

Team C. The group cohesiveness score reached its lowest point in early 1984 (Figure 10), 15 months after the team was formed. The orientation stage (1) of Team C is clear, as is its entry into the conflict stage (2). Team C was in the conflict stage (2) from mid 1983 through early 1984. There was no evidence of the beginning of the cohesiveness stage (3) when the study was completed.

The orientation stage (1) seems well defined by the field notes. In March 1983, the team leader commented, "Everybody works well and works together as a group." Evidence of team cooperation and collegiality occurred frequently in May. For example, experienced operatives offered to help others who had difficult technical assignments. Operatives were supportive in providing others with breaks. Jokes and friendly interactions were prevalent.

Complaints about team management and morale began to surface in July 1983. Some workers indicated that the team leader didn't listen well. Others felt the superintendent was unapproachable and some reported difficulty talking to him. Finding an operative to relieve one for break was increasingly viewed as the individual's own responsibility, not the team's. There was a decline in the level of cooperation among members. An example of this lack of cooperation occurred in March 1984. Because of a production problem, a worker was forced to restack an entire pallet of lids (330 bags). Four of his work group members watched from the

production office but no one offered to help. One individual complained, "[Team C] morale ha[d] gone to hell."

Intra-team conflict continued through early 1984. In this team, as on Team A, the newer operatives believed the longer-tenured operatives avoided unfavorable task assignments. Workers began to report more frequently that there were problems on the team. People were not working hard enough and not following rules.

Complaints surfaced about the superintendent and informal leader. An employee, complaining to others about the superintendent, was told, "Well, you finally woke up. The rest of us have known this for sometime." It was thought that the informal leader was becoming "too high and mighty" following completion of a difficult special assignment.

Team D. The cohesiveness scores (Figure 10) indicate that the conflict stage (2) occurred in mid 1983 for Team D, 8 months after the team was formed. The cohesiveness score dropped from 4.65 in April 1983 to 3.48 in August 1983. By December 1983, it had risen to 4.03, indicating the beginning of the cohesiveness stage (3).

Worker reactions and observed incidents support this interpretation of the developmental time frame. Until April 1983, comments such as "[Team D] will be the yardstick by which all other teams are measured" and "[Team D] is the best" were frequent. After April, negative comments by

workers about the team superintendent were reported on an internal company questionnaire. It was alleged that the superintendent "lie[d], backstab[bed], [and] turn[ed] team members against each other..." Also, team members were not as considerate in regard to relieving each other for breaks as they had been. For example, one worker explained that another won't speak up when he wants a break. The first worker feels that its the second's fault that the second doesn't get breaks. Consideration for other group members waned. The negativism on the team is reflected in a worker's response to a question from the researcher about new procedures. The employee said, "Why should you be any different from the rest of us? Why should you understand what's going on when we do not?"

By late 1983, the cohesiveness score rose from 3.48 to 4.03 suggesting that the group moved into the cohesiveness stage (3). The negative feelings seemed to be reversed. Conditions appeared to have improved. For example, an operative commented, "[Team D] is best. We are working together now." He indicated that the team had been very bad and is just now improving. It is finally getting to be a good team. A new team member said, "I never had people treat me as nice as they do here."

Implications. The four work teams moved through group development toward maturity at different rates. (See Figure 11.) For Team D the conflict stage was very short. For

may facilitate group development. The group development of Team B was smooth and calm compared with that of the other groups. Team B's superintendent had experience with plant start-up's and with the technical system.

The weak link between group development and the technological environment is not surprising given the different sphere of activity each encompasses. Group development is concerned with interpersonal relationships. Therefore, the technical environment is secondary to the interactions which occur in the development of a group from orientation to maturity.

Structure and Outcomes

Proponents of STS argue that congruence between the social and technical systems will lead to increased job performance and satisfaction (e.g. Trist, 1981; Walton, 1977). Several characteristics of the social structure, both at the individual and the group level, were examined to assess this proposition.

Group Analyses

Two structural characteristics, the overlap between the production issues communication (PIC) and social and friendship matters communication (SFMC) matrices and the dyadic stability of the work group, were used in this analysis. The first, PIC/SMFC overlap, was negatively, but not strongly significantly, correlated with group production (r_{t1}=

Team D conflict occurred early, and then cohesiveness quickly followed. For Teams A and C , the conflict stage was longer. For Team A nearly a full year passed before conflict was encountered. The results for Team B are inconclusive. The conflict stage (2) suggested by its low group cohesiveness score was unsubstantiated by the observational field notes.

Using cohesiveness scores as an indicator of group development stage, it appears that the technical system did not have a consistent effect on the development of the teams. Teams faced the same equipment difficulties and quality problems at the same time during the plant start-up. Despite encountering a common technical situation, groups solved development problems at different rates.

Advocates of STS need to recognize this phenomenon. Group development occurs in all groups. If the mature group (4) is an effective problem-solving unit, then the autonomous work group should not be maximally successful with respect to performance until they have achieved that stage. The success of an STS implementation cannot be fully measured until the work groups reach maturity. Groups progress toward maturity at their own rate and the development may take quite some time as in the case of Teams A and C which did not demonstrate movement from the conflict stage (2) to the cohesiveness stage (3) before the study's end.

Methods of fostering group development should be explored. For example, the use of experienced supervisors

-.94 ($p<.10$), r_{t2}= -.92 ($p<.10$), r_{t3}= -.75). While the sample size is small (n=4), the correlations are large. The troublesome matter is that they are in the opposite direction from that expected. It is implied in STS that congruence between the social and technical systems will be related to high production. But the results here show that congruence is related to low production.

The proportion of stable dyads within the work groups, the second structural measure, was not related to group production. The insignificant relationship between dyadic stability and performance may be attributable to the fact that this is not a crucial factor. A further problem could be the restriction of range of the dyadic stability index (0 - .076).

Individual Analyses

There was a significant correlation between dyadic membership and individual performance. Members of stable dyads had a higher supervisory performance ranking than those who were not stable dyad members. There was little change in the relationship between dyadic membership and performance after the effect of employee skill level on performance was controlled. Although the relationship is significant, the percentage of variance explained by dyadic membership is 7.8%.

Individual dyadic membership and job satisfaction were not correlated. This finding is not consistent with a

recent study on the effectiveness of the "buddy system" in socialization (Louis, Posner, and Powell, 1983). Use of the "buddy system", appointing a senior co-worker to shepherd a new initiate, was found to be significantly correlated with the job satisfaction of the new employees (Louis et al., 1983). Strictly speaking, a "buddy system" is not the same as a dyadic membership. The dyadic relationship in this study was a result of self-selection. The buddy system in the Louis et al. study was not (1983).

Implications. The relationship between group structure and performance has an interesting implication for STS. If PIC is the way in which the technical system (which relates the workers to the equipment) is enacted by the workers and SFMC is the way in which the social system (which relates the workers to each other) is enacted, then the overlap between the two may be considered the level of congruence of the sociotechnical system. If this is the case, the negative correlation between overlap and production is inconsistent with both the theory and research on STS. Higher production occurs where there is low congruence between the technical and social systems.

Previous research compares STS results with non-STS results (e.g. Trist et al., 1964; Schrank, 1974; Burden, 1975). The conventional wisdom from those studies is that an STS intervention results in higher performance than a non-STS intervention. This research examines the

differential effects of STS within a single organization. It appears that high production occurs where there is low STS congruence. Using the proxy measure (PIC/SFMC overlap), STS congruence is not having its anticipated effect.

An alternative explanation of the increase in performance may be drawn from the job characteristics model (Hackman et al., 1975). Lower absenteeism, higher satisfaction, and higher quality production are suggested where workers have jobs which are characterized by autonomy, significance, and a variety of skills. Since workers in an STS organization usually have enriched jobs with the properties of higher skill variety, higher job autonomy, and higher task identity, the performance differences in STS application may be explained by this model rather than by STS congruence. The inconsistency of the findings within STS organizations and across STS and non-STS organizations must be examined in future research.

Qualifications

Several qualifications to this study must be recognized. First, the focus of the study was the development of STS during a plant start-up. The idiosyncratic characteristics of a start-up and the single plant which was studied may limit the generalizability of the findings. The high stress associated with a plant start-up, the novel technological situation, and the intensive employee selection procedures do not generally occur in existing firms.

Next, the use of communication networks as a structural measure is somewhat new in the research of organizational behavior. Communication networks may be useful structural indicators where formal structural relationship are not defined. Further attention should be given the relationship between structural variables and organizationally relevant outcomes. A related issue concerns the difference between perceptual and objective communications. The structural communication dimensions used in this research are based on respondent's perceived communication frequencies and there may be some difference between perceived and the objective communication patterns (e.g. Bernard and Killworth, 1977).

Another qualification is time frame of analysis. The study lasted eighteen months. This period was selected because the researchers assumed stability would occur within that time. Group development in an industrial setting may take much longer. The timing of the questionnaire administrations was also a research design choice. Administrations were sometimes postponed and scales changed to accommodate a range of problems from subject fatigue to simple administration difficulties.

Finally, there is some evidence that managerial commitment to STS declined over time. Job rotation decreased, the ombudsman position disappeared, and the skill based pay system was modified. Thus, a modification of the management philosophy may have affected the results. It is difficult

to assess the independent effects of these changes in the managerial philosophy.

Summary

Chapter IV explores the results of the analyses presented in Chapter III. Several reasons were advanced for the influence of technological factors on STS. First, there seemed to be a lack of opportunity to develop strong ties based on personal characteristics. Second, the non-routineness of the task may have encouraged technically-based subgroups.

Group development seemed to occur at different rates in the different teams. The groups were not similarly affected by the technical system. A surprising finding was that high congruence between the social and technical systems was related to low group production. This finding casts doubt on the basic STS model. Finally, qualifications of the research were suggested.

APPENDIX A

JOB ASSIGNMENT MATRIX

JOB ROTATION MATRIX

Observation #_____ Date_____ Team_____
Time_____ Day of Week_____ Day of Shift___

	Team Members												
Module 1													
Shell Press 1													
Liner 1													
Liner 2													
Rotofeed 1													
Rotofeed 2													
Conversion 1													
Conversion 2													
Bagging 1													
Bagging 2													
Module 2													
Shell Press 2													
Liner 3													
Liner 4													
Rotofeed 3													
Rotofeed 4													
Conversion 3													
Conversion 4													
Bagging 3													
Bagging 4													
Module 3													
Shell Press 3													
Liner 5													
Liner 6													
Rotofeed 5													
Rotofeed 6													
Conversion 5													
Conversion 6													
Bagging 5													
Bagging 6													
QA													
Utility													
Floater													
Other													

APPENDIX B

INSTRUMENTS

COMMUNICATION NETWORK QUESTIONNAIRE

On the following pages are the names of people who work at Smithton. We are interested in how often you communicate with each person about different things. This questionnaire refers to formal as well as informal communication.

Please put your social security number in the space provided. Then, using the Communication Frequency Scale listed on each page, indicate how often you communicate with each person about production issues. Repeat this procedure for social and friendship matters. If you do not communicate with a particular person, just leave a blank next to his or her name.

As you can see, we are only asking you to indicate communication in two areas, rather than four areas as in the past. We appreciate your continued help.

HOW OFTEN DO YOU COMMUNICATE WITH THESE PERSONS?

Communication Frequency Scale

6- Several times a day
5- Once or twice a day
4- Several times a week
3- Once a week
2- Several times a month
1- Once a month

	Production Issues	Social & Friend-ship Matters
Ken		
Hugh		
Dave		
Bob		
John		
Ken		
Jerry		

	Production Issues	Social & Friend-ship Matters
Dave		
Dave		
Gary		
Ken		
Sally		
Warren		
Pete		

WORK AS A CENTRAL LIFE INTEREST

BELOW IS A SERIES OF STATEMENTS. EACH STATEMENT HAS THREE POSSIBLE RESPONSES. INDICATE YOUR ANSWER BY A CHECK MARK IN THE SPACE TO THE LEFT. BE SURE TO CHECK ONE SPACE FOR EACH STATEMENT, EVEN IF NONE OF THEM EXACTLY FITS YOUR OWN IDEAS. CHOOSE THE RESPONSE WHICH MOST NEARLY APPROXIMATES YOUR VIEWS ON THE STATEMENT.

1. Interruptions bother me most

   1 when working at my job
   0 when working at home
   0 hardly ever

2. I do my best work

   1 when I am at my job
   0 when I'm not bothered by people
   0 when I work around the house or on a community project.

3. I would rather accept a committee chairmanship

   0 anytime, any place
   1 of a company, operating, or advisory committee
   0 in an organization or club of which I am a member

4. When I am doing some work, I usually try not to waste time

   0 I seldom worry about wasting time
   0 on a project at home or in the community
   1 on my job

5. I believe that

   0 helping my fellow men is more important than anything else
   1 my career is more important than anything else
   0 most things are about equally important

6. In my free time at work, I would rather

0 talk about whatever comes up
1 talk about things I am working on in the company
0 talk about things that are going on in sports or politics

7. I am most interested in

1 things about my job
0 things I usually do around the house or in the community
0 just about everything I do

8. I most enjoy keeping

0 my things around the house in good shape
0 my mind off such things
1 my hand tools and work-space on the job in good shape

9. I prefer to have as friends

1 people I get to know in my work
0 people who share my leisure interests
0 different people according to what they're like

10. Moving ahead on my job

0 is not so important to me that I would give up my time to make contacts and pick up information about my work
1 is so important to me that I'm willing to spend extra time to make contacts and pick up information about my work
0 is not particularly important to me

11. If I received a promotion that meant moving to another city

0 my friendships wouldn't make any difference in my moving
1 I would most dislike leaving my friends on the job
0 I would most dislike leaving my other friends

12. The people I can count on most when I need help are

1 the friends I have at work
0 the friends I have in the community
0 almost any of my friends

13. When I am worried, it is usually about

1 how well I am doing in my career
0 just little things
0 things that happen at home

14. When I am not with them, the people I miss most are

0 just people in general
0 my friends around town
1 my friends with whom I work

15. I am happier if I am praised for doing a good job of

1 something at work
0 something in an organization I belong to
0 anything, it doesn't matter very much what

16. If I were sick and had to stay home, I would most hate

1 missing a day's work
0 missing almost anything I usually do
0 missing a meeting of an organization I belong to

17. The most pleasant things I do are concerned with

0 relaxation
1 my career
0 different things at different times

18. I hope my children can

1 work in the same kind of occupation as mine
0 work in any occupation, just so they enjoy their work
0 work in a different kind of occupation from mine

19. In my spare time

0 I just prefer to relax
1 I often think of better ways of doing my work
0 I have a thousand things that need doing

20. I sometimes hope that

1 I'll get special recognition for doing a good job at work
0 I'll get to be a more important member of my club, church, or lodge
0 such things will not bother me

21. If I needed ready cash within a few hours for an emergency on a Sunday and had to borrow it, I would probably turn to

0 people I know in the community
1 people I know in the company
0 anyone who would lend it to me

22. It is easier for me to take a chewing out

0 from anyone--I listen and forget it
0 from a policeman
1 from my boss

23. I would donate more money in the case of a collection

0 if the solicitor was a friend of mine
0 for a charitable organization
1 for a wedding present or retirement gift for a colleague at work

24. If I have to work with someone else who is a slow worker

0 I am annoyed regardless of where we are working
1 I am most annoyed on a job at my work place
0 I am most annoyed on a volunteer community project

25. In getting a job done, it is most important for me to have adequate freedom to plan it

1 on my job
0 on a community project
0 anytime, any place

26. I would rather take my vacation with

1 some friends from work
0 my family
0 by myself

27. I most like

0 talking with friends about things that are happening
0 talking about whatever my friends want to talk about
1 talking with my friends about my work and what is happening in the company

28. In order to get ahead in the world

0 you have to have a lot of luck
1 you have to be well liked where you work
0 you have to be well liked and known in the community

29. If a company project I knew about but was not involved in gave everybody trouble, and I heard another company had solved this problem

0 I have too many problems of my own to get involved
1 I would tell my boss or colleagues about it
0 I don't worry about such things

30. I think that if I were suddenly to get a much better job

0 probably my life would not change much except that I'd live a little better
1 probably my life would change and be better in many ways
0 I wouldn't know what would happen to my life

31. I would much rather be a leader

0 in any organization, just so it's a good one
0 in my club or church
1 in my work

32. I enjoy reading technical articles and books to learn more about

0 only something very special and important
0 my hobby or other interests
1 my job

Source: Dubin (1956).

GROUP COHESIVENESS

WE WANT TO KNOW SOME THINGS ABOUT YOUR TEAM.

A. DECIDE HOW WELL THE STATEMENT DESCRIBES YOUR TEAM.

B. DRAW A CIRCLE AROUND ONE OF THE FIVE NUMBERS FOLLOWING EACH STATEMENT TO DESCRIBE THIS TEAM AS ACCURATELY AS YOU CAN.

5= ALWAYS
4= VERY OFTEN
3= ABOUT AS OFTEN AS NOT
2= SELDOM
1= NEVER

1.	The members of this Team regard each other as friends	1 2 3 4 5
2.	The members of the Team are very co-operative with each other	1 2 3 4 5
3.	The Team members know that they can depend on each other	1 2 3 4 5
4.	The Team members stand up for each other	1 2 3 4 5
5.	Members of this Team work together as a team	1 2 3 4 5

Source: Stogdill (1965).

JOB SATISFACTION

NOW WE WOULD LIKE TO GIVE YOU A CHANCE TO TELL HOW YOU FEEL ABOUT YOUR PRESENT JOB, WHAT THINGS YOU ARE SATISFIED WITH AND WHAT THINGS YOU ARE NOT SATISFIED WITH. PLEASE CIRCLE THE NUMBER THAT ACCURATELY REFLECTS YOUR ATTITUDES.

ON MY PRESENT JOB, THIS IS HOW I FEEL ABOUT:

	Very Dissatisfied				Very Satisfied
1. Being able to keep busy all the time	1	2	3	4	5
2. The chance to work alone on the job	1	2	3	4	5
3. The chance to do different things from time to time	1	2	3	4	5
4. The chance to be "somebody" in the community	1	2	3	4	5
5. The way my boss handles subordinates	1	2	3	4	5
6. The competence of my supervisor in making decisions	1	2	3	4	5
7. Being able to do things that don't go against my conscience	1	2	3	4	5
8. The way my job provides for steady employment	1	2	3	4	5
9. The chance to do things for other people	1	2	3	4	5
10. The chance to tell people what to do	1	2	3	4	5

	Very Dissat-isfied				Very Satis-fied
11. The chance to do something that makes use of my abilities	1	2	3	4	5
12. The way company policies are put into practice	1	2	3	4	5
13. My pay and the amount of work I do	1	2	3	4	5
14. The chances for advancement on this job	1	2	3	4	5
15. The freedom to use my own judgement	1	2	3	4	5
16. The chance to try my own methods of doing the job	1	2	3	4	5
17. The working conditions	1	2	3	4	5
18. The way my co-workers get along with each other	1	2	3	4	5
19. The praise I get for doing a good job	1	2	3	4	5
20. The feeling of accomplish-ment from the job	1	2	3	4	5

Modified from Weiss, Dawis, England and Lofquist (1967)

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Henry L. Tosi, Chairman
Professor of Management

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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May, 1987

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